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Resistance and Stock Propulsion on the High Speed Sealift (HSS) Hybrid Contra-Rotating Shaft-Pod (HCRSP) Concept, Model 5653-3A

By
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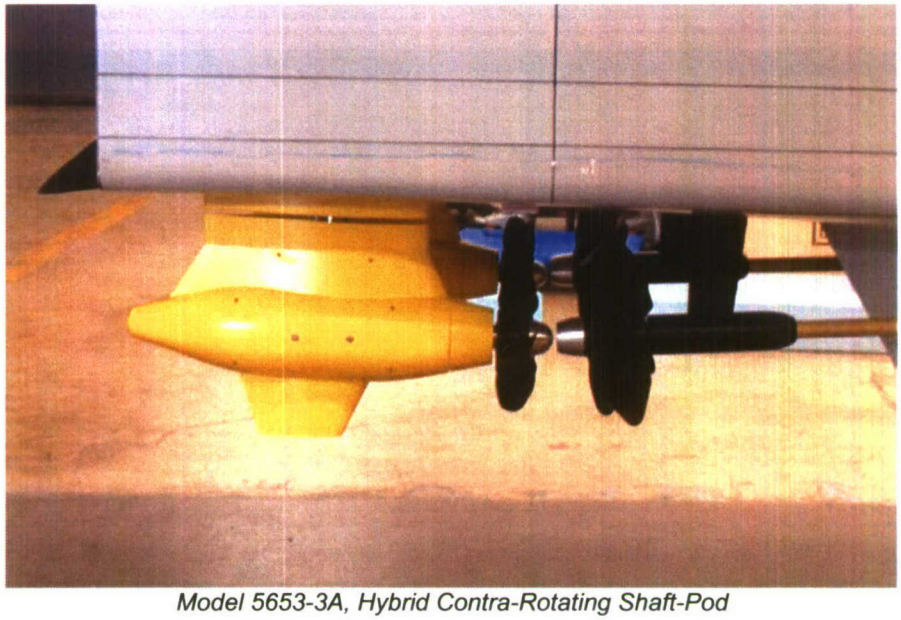

Model 5653-3A, Hybrid Contra-Rotating Shaft-Pod

NSWCCD-50-TR–2008/027 Resistance and Stock Propulsion on the High Speed Sealift (HSS) Hybrid Contra-Rotating Shaft-Pod (HCRSP) Concept, Model 5653-3A

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14. ABSTRACT

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At the selected forward-to-aft propeller RPM ratio of 1:1, design displacement, it is predicted that the HSS HCRSP will require a total delivered power, shafts and pods, of 196,111 hP (146.2 MW), at a propeller rotational speed of 110.4 RPM (forward and aft propellers) to attain the 39-knot design objective speed.

For the 39-knot objective speed, design displacement, the HSS HCRSP exhibited 9.8% reduction in total delivered power relative to the Joint High Speed Sealift (JHSS) baseline shaft & strut (BSS), a conventional 4-screw open propeller design that shares the same parent sealift hullform. Average reduction in delivered power over the speed range, for the HSS HCRSP relative to JHSS BSS, was 14%.

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ABSTRACT

A series of model-scale resistance and propulsion experiments were conducted on a Hybrid Contra-Rotating Shaft-Pod (HCRSP) candidate propulsion configuration on a High Speed Sealift (HSS) hullform, as represented by Model 5653-3A. The HCRSP concept consists of two pairs of contra-rotating propellers, where the forward propellers are arranged on conventional shaftlines, and the aft propellers are powered by propulsion pods.

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ADMINISTRATIVE INFORMATION

Funding was provided by the US Navy's Sealift R&D Program through the Strategic & Theater Sealift Program Office PMS 385. The Sealift R&D Hydro Working Group (HWG) coordinated all hydrodynamic, propulsion, and structural loads R&D for the combined efforts under several US Navy sealift programs. The model-scale tests were conducted at the David Taylor Model Basin, Naval Surface Warfare Center, Carderock Division (NSWCCD), by the Resistance & Propulsion Division (Code 5800), under work unit number 07-1-2125-144.

INTRODUCTION

The need for high speed, heavy payload capable, long distance transportation, referred to as high speed sealift mission profiles, has spurred the exploration of alternative ship designs as well as non-conventional propulsion designs on monohulls. The high speed sealift mission profile is broadly described as being able to "Embark design payload, transport it 8,000 nm at 36 knots or more, and disembark it to a seabase or shore facility" [Ref. 1]. A notional 977 ft (298 m) High Speed Sealift (HSS) ship, with a threshold speed of 36 knots and an objective (design) speed of 39 knots, was designed as the monohull parent platform for the evaluation of the different candidate propulsion arrangements.

This document contains the results from a series of model-scale experiments to evaluate the Hybrid Contra-Rotating Shaft-Pod (HCRSP) candidate propulsion configuration on the High Speed Sealift (HSS) ship. The experiments, as presented in the Test Agenda, Appendix A, Table A1, were conducted on Model 5653-3A. The HSS HCRSP concept propulsion system consists of two pairs of azimuthing tractor propulsion pods, with propellers installed forward of the pod body, arranged directly behind conventional open propellers supported by open shaftlines and struts. Each pair of propellers, forward shaftline-driven and aft pod-driven, which rotate in opposite directions, form a contra-rotating pair, as shown in the computer renderings of Figure 1. Additional concept renderings are presented in Appendix A, Figure A1.

The current model-scale experiments will also be used to assess the relative performance merits between the HSS HCRSP propulsion configuration and that of a conventional 4-screw open propeller configuration previously tested on this monohull parent platform, referred to as the Joint High Speed Sealift (JHSS) Baseline Shaft & Strut (BSS) [Ref. 2]. The contra-rotating

propeller hybrid variant should exhibit a distinct advantage in terms of propulsion efficiency when compared to the open propeller hullform.

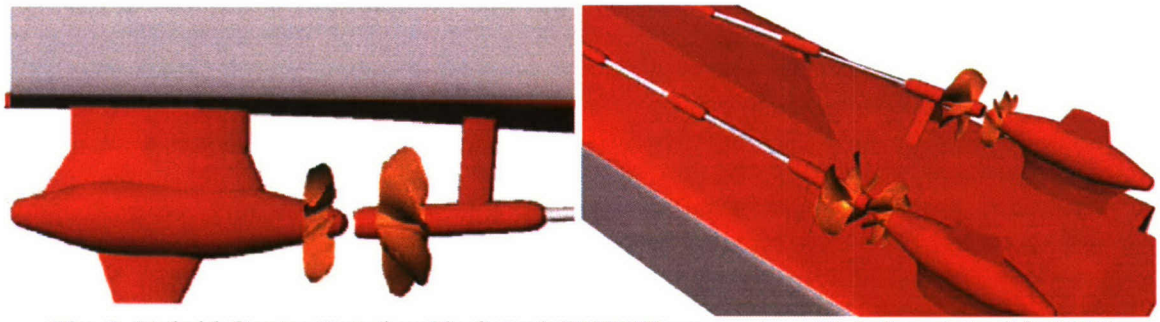

Fig. 1. Hybrid Contra-Rotating Shaft-Pod (HCRSP) concept on High Speed Sealift (HSS)

BACKGROUND

A conventional single propeller causes a significant amount of rotational flow, the energy of which is wasted as it flows downstream. To utilize this wasted energy, the placement of a second propeller behind the first, rotating in the opposite direction, referred to as a contra-rotating propeller pair, takes advantage of the rotational flow. If ideally designed, a contra-rotating propeller pair will have no rotational flow aft of the second propeller disk, resulting in low induced energy loss and high efficiency.

In the customary application of contra-rotating propellers, the power of the propulsion engine(s) is applied down a single coaxial shaftline to drive two propellers, arranged one behind the other, which rotate in opposite directions. The desirability of conventional contra-rotating propellers is somewhat decreased by the mechanical complexity required of the coaxial shaftline drive system, and induced problems with expensive gear sets, bearings and seals. Using a pod to drive the aft propeller of a contra-rotating set allows for the hydrodynamic benefits of contra-rotation without the shafting and gearing issues. The forward propeller can be driven by either a mechanical driven unit (diesel or gas turbine engines) or by electric motors using electric power from a power generation plant. The aft propeller is driven by a pod, using an electric motor in the pod, again supplied with electric power from the power generation plant. The two propellers are driven by separate systems, thus avoiding the complexities of the coaxial drive system.

The high-speed ferry "Hamanasu", equipped with a hybrid controllable-pitch propeller and pod (CRP-POD) contra-rotating propulsion system, was recently tested in Japan, Figure 2. It was reported that, with this system, the energy savings amounted to more than 13% when compared to the conventional twin shafts and propellers system [Ref. 3]. In addition, it was reported that in the hybrid CRP-POD propulsion system, the azimuthing pod unit could provide significant lateral force in any direction, meaning that maneuvering within harbors and other confined waterways was much easier than with conventional open screw propulsion [Ref. 4].

Fig. 2. High-speed ferry "Hamanasu" with hybrid CRP-POD propulsion system

HULL MODEL

The HCRSP experiments were conducted on Model 5653-3A. The current model utilizes the equivalent JHSS Baseline Shaft & Strut (BSS) parent hullform Model 5653. Model 5653, the parent hullform utilized for the current testing, was built of fiberglass at NSWCCD to a linear scale ratio λ = 34.121 and length between perpendiculars (LBP) = 27.86 ft. A detailed description of Model 5653, and photographs while under construction, are presented in Reference 5. The suffix '3' affixed to the model number denotes the installation of the Gooseneck Bulb, selected as the optimal tested bow design for the JHSS hullform [Ref 5]. The secondary suffix 'A' denotes the installation of the Hybrid Contra-Rotating Shaft-Pod (HCRSP) model-scale propulsion system, as described below.

To induce turbulent flow along the model, turbulence stimulator studs of 1/8-inch diameter by 1/10-inch height, spaced 1 inch apart, were affixed to the model approximately 2-inches aft of the stem, and continuing down to and around the bulb approximately 2 inches aft of the FP.

Resistance and powering experiments were conducted on HSS Model 5653-3A at a design displacement (DES) of 36,491 tons, static even keel (zero trim), equivalent to that of the JHSS baseline shaft & strut (BSS) design displacement. Two alternative displacements were also tested, a heavy displacement (HVY) of 40,140 tons and light (LITE) displacement of 32,841 tons, representing $\pm$10 percent variations in displacement from design. These alternative displacements were also equivalent to those tested for the JHSS BSS design. Static even keel was maintained for all displacement conditions. Ship/model test conditions are presented in Appendix A, Table A2.

Hybrid Contra-Rotating Shaft-Pod (HCRSP) Design

The current HCRSP configuration on the HSS is envisioned to consist of a 50 MW motor driving each of the shaft-mounted forward propellers (two total), and two 25 MW azimuthing tractor pods driving the aft propellers, totaling a combined 150 MW (201,180 hP). The selected forward-to-aft propeller RPM ratio is 1:1, and the installed power ratio between the main shaft mounted forward propeller and pod driven aft propeller is approximately 2:1 for this design.

The pod barrels were designed with their noses angled 1.8 degrees down relative to the ship baseline in order to align with bulk flow rising along the ship's buttocks. The centerlines of the pod fairwaters were vertically aligned with the centerline of the shaftline fairwaters. In the horizontal plane of the ship, both the shafts and pods were aligned 1-degree trailing edges outboard so that the shaftlines penetrated the hull approximately halfway between the ship's centerline and the turn of the bilge. In the vertical plane of the ship, the shafts are angled 2.3 degrees upwards relative to baseline in order to match the characteristics of the four-screw design. A schematic of pod and shaftline angles is presented in Figure 3.

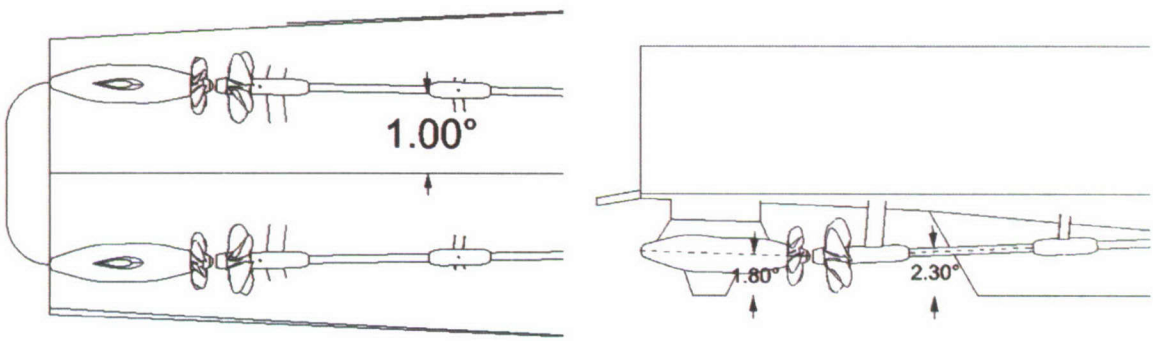

Fig. 3. Schematic of pod and shaftline angles

The commercial off the shelf (COTS) azimuthing pods being considered in this study are manufactured by ABB Marine & Turbocharging. The initial geometry was provided by ABB and modified according to published dimensions of the Type 28 pod [Ref. 6]. The geometry was further modified to smooth the transition between the pod barrel and the tapered ends to improve high speed drag and cavitation characteristics, and the forward portion of the pod was elongated by 1.6ft (0.5m) to assure adequate clearance between the front of the support strut and the trailing edge of the propeller. This was accomplished by reducing the taper angle of the forward section of the pod, which also had the effect of reducing the hub diameter of the propeller.

Each model-scale propulsion pod consists of a stainless steel transmission dynamometer and right angle gear drive (manufactured by Force Technology of Denmark) within an outer shell of plastic resin. A photograph of an example model-scale propulsion pod, dynamometer, right angle gear drive, and X-Y force gage, from the application on the Mobile Landing Platform (MLP) Model 5664, [Ref 7], is presented as Figure 4.

The resin shells are constructed using stereo lithography apparatus (SLA). Each shell splits along its centerline to allow access to the dynamometer. For the HCRSP application, the gray resin shell halves depicted, in the Figure 4 MLP photograph, were replaced by yellow-painted shells correctly designed and sized for Model 5653-3A.

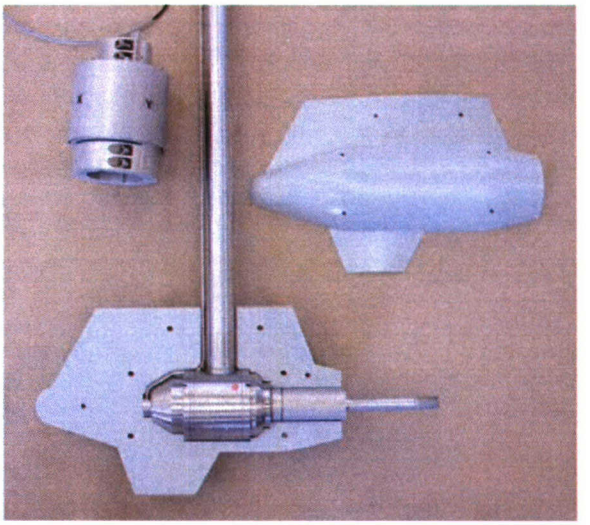

Fig. 4. Example Pod dynamometer in SLA pod shell and X-Y force gage (MLP Model 5664)

Photographs of HSS Model 5653-3A, with the HCRSP propulsion configuration installed, and the stock contra-rotating propulsor design (model propeller series 5513-14-15-16), are presented in Figure 5, with additional photographs presented in Appendix A, Figure A2.

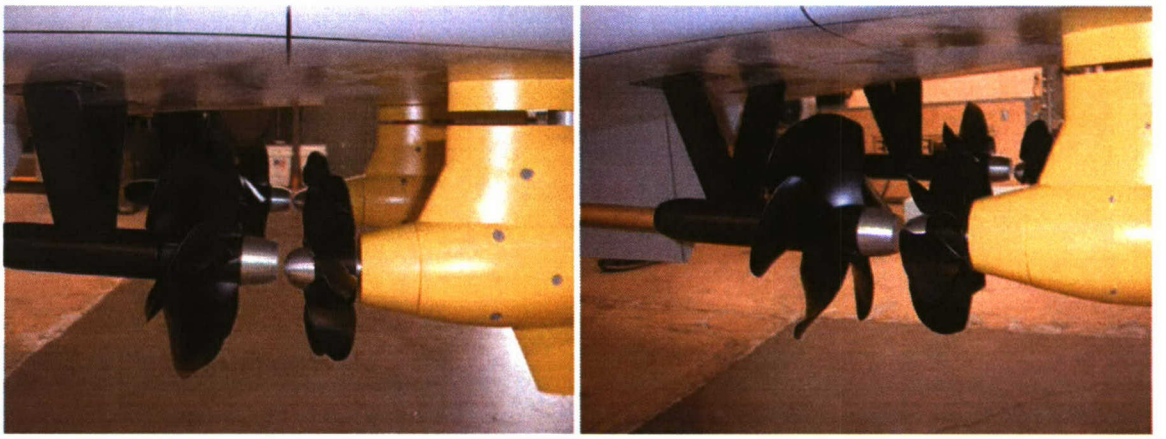

Fig. 5. HSS Model 5653-3A equipped with HCRSP propulsion configuration and stock contra-rotating model propeller series 5513-14-15-16

Pod steering (azimuth) angle is adjustable through the fixture mounted inside the model. This fixture allows for steering angle adjustment and the measurement of pod forces in two orthogonal directions, X and Y. The X-Y force gage, and thus the force measurement reference, rotates with pod steering angle.

Separate from the steerable, azimuthing pod is a pod shoe, which was fixed to the hull at a 1 degree inboard yaw angle (parallel to the shaftlines).

Stock Contra-Rotating Propulsor Design

A stock propulsor has been designed for the HSS Hybrid Contra-Rotating Shaft-Pod. Details of the stock Propulsor design are presented in Reference 8. The forward propeller of the contra-rotating set is a standard shaft and strut mounted propeller. The aft propeller is driven by a COTS tractor pod.

The aft propeller is smaller in diameter than the forward propeller to ensure that the entire aft propeller operates in the slipstream of the forward propeller. The final full-scale design has a 21.5 ft diameter, five-bladed propeller forward and a 17 ft diameter, seven-bladed propeller aft.

The full power design speed for this stock contra-rotating Propulsor design is 39 knots. Calculations predict that the design will achieve the 39-knot target speed without significant thrust breakdown.

Stern Flap

The decision was made by the HWG to conduct the fully appended experiments on Model 5653-3A with the installation of a stern flap. The stern flap utilized was that selected as the stern flap design for the JHSS BSS, Model 5653-3 [Ref. 2]. This stern flap has full-scale dimensions of chord length 12.8ft (3.9m) equivalent to 1.35% LWL, span 52.9ft (16m) representing 80% of the maximum span, and an angle of 10° trailing edge down relative to the local buttock slope at the centerline of the transom.

Instrumentation

The linear bearing, floating platform "Cusanelli" tow post [Ref. 9], was utilized for the forward attachment point of the model to the towing carriage. Mechanical connection between the tow post and model was made through a double-axis gimbal assembly. The location of the model tow point was at ship Station 5, parallel to, and at the same level as, the original 8.6m (28.22ft) DWL. For the aft attachment point, the standard 'grasshopper' bracket was utilized, attached at ship Station 15. The counter weights and vertical arm were balanced, in place, so that the arm would not impart any vertical force on the model. When attached through this tow system, the model is restrained in surge, sway, and yaw, but is free to pitch, heave, and roll.

Model resistance (drag) measurements were collected using a DTMB 4-inch block gauge, of 100 lbf. capacity. Model side force measurements were collected with a DTMB 4-inch block gauge, of 50 lbf. capacity. Side force is monitored at the tow post attachment point during calm water experiments in order to maintain an essentially zero side force to insure zero yaw angle. Dynamic sinkage (defined as positive downward) was measured by wire potentiometers, which were located at the intersection of the deck line at Station 1 forward and Station 15 aft.

Thrust and torque on the forward (shaft mounted) propellers were measured with Kempf and Remmer's (Cussons Technology) model R33 dynamometers, of 90 lbf. thrust (T) / 130 in-lbf. torque (Q) capacity. To insure equivalent shaft rotational speed (RPM), the port and starboard forward propeller shafts were driven through 1:1 drive ratio "T" gearboxes and coupled so that both were powered by a single electric drive motor. A 60 tooth wheel and magnetic pickup / pulse counter system was used to determine shaft RPM. Shaft rotation for the forward propellers was outboard-over-the-top.

Thrust and torque on the aft (pod driven) propellers were measured with specially-designed pod transmission dynamometers, of 177 lbf. thrust (T) / 112 in-lbf. torque (Q) capacity, manufactured by Force Technology of Denmark. The two pods were driven by right angle gear sets and motors also supplied by Force Technology. The pod drive motors were electronically

synchronized to maintain equivalent RPM. Shaft rotation for the aft pod driven propellers was inboard-over-the-top.

The two pod drive motors were, in turn, electronically synchronized with the single shaftline electric drive motor, in order to maintain the desired forward-to-aft propeller (F:A) RPM ratios. Throughout the bulk of the powering tests herein, a F:A RPM ratio of 1:1 was maintained. Additional single powering tests were conducted at the following F:A RPM ratios; 0.95:1, 0.975:1, 1.025:1, and 1.05:1. The test engineers monitored the F:A RPM ratio synchronization during every test run to insure that the actual measured model F:A RPM ratios remained within $\pm$1% of the desired value for that test particular test condition. Model test data outside of this tight criterion were discarded and the run conditions were repeated.

Calibration of all aforementioned instrumentation was performed prior to the tests in the NSWCCD Code 5800 calibration lab.

RESISTANCE

Tests were conducted on Model 5653-3A in the NSWCCD Deepwater Towing Basin #2 using Carriage 2. The ship-model correlation allowance of C_A = 0.0 was recommended by NSWCCD Code 5800 based on the NAVSEA guidance as modified by more recent correlation allowance experience. The value of C_A = 0.0 was agreed upon by the HWG. Predictions are made for the full-scale HSS operating in smooth, deep, salt water, with a uniform standard temperature of 59°F. As with standard NSWCCD practices, the external surface area of the two pods were included in the appended ship total wetted surface used in the calculation of ship frictional resistance, whereas the surface areas of the forward propeller shaftlines and struts were not included.

Resistance experiments were conducted on Model 5653-3A, fully appended, equipped with HCRSP propulsion configuration, at the three aforementioned displacements, DES, HVY, and LITE, the results of which are presented in Appendix A, Tables A3-A5. Relative to the fully appended DES condition, the 10% increase in displacement (HVY) resulted in a 9.3% average increase in resistance across the speed range, and conversely, the 10% reduction in displacement (LITE) resulted in an average 4.0% reduction in resistance.

Fully appended experiments on Model 5653-3A were conducted with the installation of the selected stern flap design. Stern flap optimization experiments were not conducted on Model 5653-3A with HCRSP propulsion. A resistance experiment conducted on Model 5653-3A, at DES, with the stern flap removed, Table A6, indicated that the flap effected an average resistance reduction across the speed range of 2.3%, a maximum resistance reduction of 5% at 34-35 knots, and at the 39 knot design speed reduced the resistance by 4.3%.

A resistance experiment was conducted, at DES, after the two propulsion pods were removed from the model, Table A7. The effective increase in resistance due to the pods averaged 13.2% over the speed range. At the design speed of 39 knots, the increase in resistance due to the two pods was 10334 hP (12.3%). The pod resistance, as measured, was lower than that estimated in the pre-test calculations using formulae supplied by the pod manufacturers. It is speculated that the presence of the forward propeller shaftlines directly in front of the propulsion pods, in effect, placed the pods into an area of heavy wake shadow, thus reducing the expected resistance of the pods.

One final resistance experiment was conducted with the twin shaftlines removed, Table A8. The effective increase in resistance due to the shaftlines averaged 11.6% over the speed range, and effected an increase of 8.6% at 39 knots.

Summaries and comparisons of all of the resistance experiments conducted during the current experimental series are presented in Appendix A, Tables A9-A10. The resistance effects of the

various appendages installed on HSS HCRSP Model 5653-3A are summarized, at the design speed of 39 knots, in Table 1.

Table 1. Resistance effects of appendages installed on HSS HCRSP Model 5653-3A, at 39-knot design speed

Base Hull (with Bilge Keels)	Twin Shafts & Struts Installed	Two Propulsion Pods Installed	Stern Flap Installed (Fully Appended)
PE (hP)	PE (hP)	PE (hP)	PE (hP)
120427	130760	146873	140564
	+10334	+16113	-6309
	+8.6%	+12.3%	-4.3%

POWERING

A total of sixteen different HCRSP powering conditions were tested on HSS Model 5653-3A, including variations in ship displacement, pod alignment, pod steering, and forward-to-aft propeller RPM ratios, as outlined in Table 2. With the exception of the two displacement variation tests listed, all of the remaining powering conditions were examined at design displacement. The selected forward-to-aft (F:A) propeller RPM ratio was 1:1, and was therefore maintained throughout the bulk of the powering tests. Comparisons of all of tested powering conditions are presented in Appendix A, Figure A3, and in Tables A25-A31.

Note: The NSWCCD conventional 4-screw data collection and analysis programs were adapted for use during the HCRSP model tests and analysis. Therefore, in the output tables of Appendix A, any reference to "inboard" shafts and/or propellers refers to the forward shaftline propellers, and subsequently, and reference to "outboard" refers to the pod aft propellers.

Table 2. HSS Model 5653-3A, HCRSP powering conditions tested

Displacement Variations	Heavy	Design		Light	
Pod Alignment*	2.5° Inbd	0° (Design)	2.5° Outbd	5° Outbd	F:A RPM Ratio =1:1
Pod Steering*	0° (Design)	2.5° Stbd		5° Stbd	
Stern Flap Evaluation	Stern Flap Installed		No Stern Flap		
Pod Bearing Forces*	0° (Design)	30° Outbd	60° Outbd	90° Outbd	
Fwd:Aft Prop RPM Ratios	0.95:1	0.975:1	1:1	1.025:1	1.05:1
* Pod Leading Edge (LE) Rotation Angle Relative to Design Alignment of 1° LE Inbd.					

Results of the HSS HCRSP powering experiments at the three displacements, DES, HVY, and LITE, are presented in Appendix A, Tables A11-A13. For the 39-knot design speed, the resultant powering is presented in Table 3. These three tests were conducted with the design F:A propeller RPM ratio of 1:1.

Table 3. HSS HCRSP powering at 39 knots, three tested displacements

	Heavy (HVY)		Design (DES)		Light (LITE)	
Total Delivered Power, hP, MW	212754	158.6	196111	146.2	187932	140.1
Power Variation, %	+8.5%		-		-4.2%	
Fwd/shaft RPM, MW	112.4	*50.2*	110.4	46.5	109.4	43.9
Aft/shaft RPM, MW	112.4	*29.1*	110.4	*26.7*	109.4	*26.1*
Note: Numbers appearing in *Italics* indicate values exceeding motor limits.						

The full power speed for this stock contra-rotating propulsor design is 39 knots. Propulsor calculations predict that the design will achieve the 39-knot speed without significant thrust breakdown [Ref 8]. When at the selected forward-to-aft propeller RPM ratio of 1:1, DES

displacement, Figure 6, it is predicted that the HSS HCRSP will require a total delivered power, shafts and pods, of 196,111 hP (146.2 MW), at a propeller rotational speed of 110.4 RPM (both forward and aft propellers) to attain the 39-knot design speed. For the forward propellers, the predicted power/shaft is 46.5 MW, while the predicted power for each pod-driven aft propeller is 26.7 MW. At the selected F:A propeller RPM ratio of 1:1, the load-sharing ratio between the main shaft mounted forward propellers and pod driven aft propellers is 1.74 for this design.

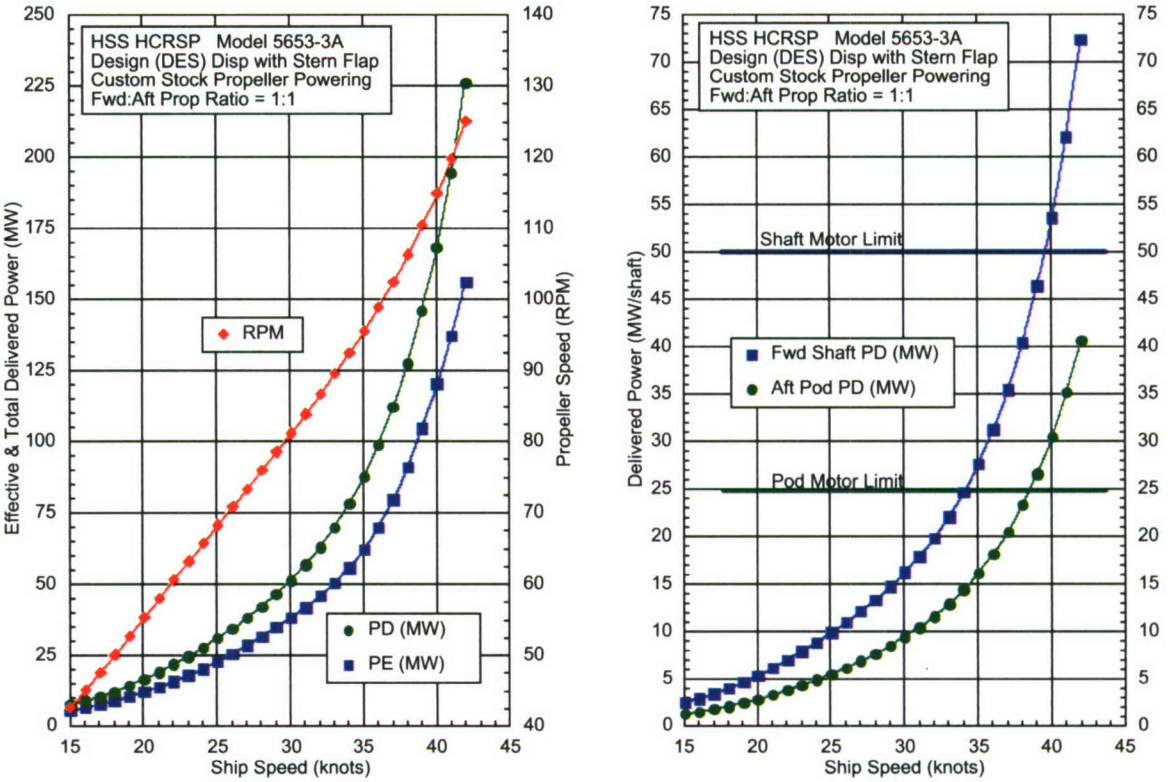

Fig. 6. HSS HCRSP powering at DES displacement

The current HCRSP configuration on the HSS is envisioned to consist of two 50 MW motors, one driving each of the shaft-mounted forward propellers, and two 25 MW azimuthing tractor pods driving the aft propellers. Experimental results indicate that, to attain 39 knots, the available power of the propulsion pods would need to be exceeded. Maximum speed attainable, when the criterion of equal forward-to-aft propeller RPM is observed, is indicated to be 38.5 knots, where the pods reach their maximum output of 25 MW, while the forward shaftline motors deliver 43.4 MW each, with both propellers at a rotational speed of 108.4 RPM.

Propulsor calculations for the HSS HCRSP stock propeller design [Ref 8] indicated that the 39-knot design speed was expected to be achieved with a total delivered power of 191,500 hP (143 MW) at a propeller rotational speed of 113 RPM. A final propulsive coefficient (ηD) of 0.716 was calculated at 39 knots, nearly equivalent to that determined by the model measurements, ηD of 0.717.

Relative to the DES condition, the 10% increase in displacement (HVY) resulted in a 12.1% average increase in total delivered power across the speed range, and conversely, the 10% reduction in displacement (LITE) resulted in an average 2.8% reduction in power. The minimal reduction in power at the light displacement may be due to the presence of the hydrodynamic bulb. This bulb projects slightly above the still water surface at design displacement, therefore,

at the lighter displacement, the closer proximity to the water surface at all speeds may have a detrimental contributing factor to the ship's resistance and powering.

Fwd-to-Aft Propeller RPM Ratio Variations

In addition to the DES displacement powering test conducted at the selected forward-to-aft (F:A) propeller RPM ratio of 1:1, additional powering tests were conducted at the following F:A RPM ratios; 0.95:1, 0.975:1, 1.025:1, and 1.05:1. Resultant powering data for these propeller ratio variations are presented in Appendix A, Tables A14-A17, and for the 39-knot design speed, in Table 4.

Model tests indicated that increasing the load on the forward propellers, F:A RPM ratios 1.025:1 and 1.05:1, reduced the required total delivered power in the lower portion of the speed range, while conversely, increasing the load on the aft pod propellers, F:A RPM ratios 0.95:1 and 0.975:1, reduced the required total delivered power in the upper portion of the speed range. However, on average across the entire speed range, the delivered power exhibited by all five tested propeller RPM ratios did not differ by more than $\pm$1%.

At the 39-knot design speed, the two F:A RPM ratios of 0.95:1 and 0.975:1 showed a substantial reduction in total delivered power. However, for both of these conditions, 39 knots is not attainable, because the available power of the propulsion pods would need to be exceeded.

Table 4. HSS HCRSP powering at 39 knots, variations in forward-to-aft propeller RPM ratios

Fwd:Aft RPM Ratio:	**1.05:1**		**1.025:1**		**1:1**		**0.975:1**		**0.95:1**	
Total Delivered Power, hP, MW	195904	146.1	195123	145.5	196111	146.2	189611	141.4	186201	138.8
Power Variation, %	-0.1%		-0.5%		-		-3.3%		-5.1%	
Fwd/shaft RPM, MW	112.1	*50.6*	111.4	47.8	110.4	46.5	109.2	42.0	107.3	40.5
Aft/shaft RPM, MW	106.7	22.5	108.6	24.9	110.4	*26.7*	111.9	*28.7*	112.9	*28.9*
Fwd/Aft Load-Sharing Ratio	2.25		1.92		1.74		1.46		1.40	

Note: Numbers appearing in *Italics* indicate values exceeding motor limits.

Forward-to-Aft Propeller RPM Ratio Scheduling

A careful assessment of the model-scale data on the relative powering performance of the HCRSP system due to variations in forward-to-aft (F:A) propeller RPM ratios, indicated the following:

- Increasing the F:A propeller ratio (forward propeller RPM greater than aft propeller RPM) decreased the total delivered power in the lower portion of the speed range (below 21 knots).
- The design F:A propeller ratio of 1:1 appeared to be optimal through most of the mid-portion of the speed range (22 to 36 knots).
- Decreasing the F:A propeller ratio (forward propeller RPM less than aft propeller RPM) decreased the total delivered power in the upper portion of the speed range (above 36 knots). However, for these F:A propeller ratios, the speeds above 37 knots are not attainable, because the available power of the propulsion pods would need to be exceeded.

Presented in Table 5 is the forward-to-aft propeller (F:A) rpm ratio scheduling, as indicated in the model-scale tests, for minimum power presented in the first column, followed by the F:A propeller ratio required to make speed while remaining within the actual capabilities of the propulsion motors (without exceeding the capacities of the propulsion pods or shaftlines).

Table 5. HSS HCRSP forward-to-aft propeller rpm ratio scheduling

	"Best" Perfomance		Actual Capability	
VS (kts)	F:A Ratio	PD (hP)	F:A Ratio	PD (hP)
15	1.025:1	10152	1.025:1	10152
20	1.025:1	21714	1.025:1	21714
25	1:1	41614	1:1	41614
30	1:1	69108	1:1	69108
36	1.05:1	130211	1.05:1	130211
39	0.95:1	186201	1.025:1	195123
42	0.95:1	265374	-	-

Top Speed Attainable

The current HCRSP configuration on the HSS is envisioned to consist of two 50 MW motors, one driving each of the shaft-mounted forward propellers, and two 25 MW azimuthing tractor pods driving the aft propellers. At the selected forward-to-aft (F:A) propeller RPM ratio of 1:1, the model-scale tests indicate that the load-sharing ratio between the main shaft mounted forward propellers and pod driven aft propellers is 1.74 over the upper end of the speed range. This load-sharing inequity relative to the installed propulsion power ratio (2:1) causes the available power of the propulsion pods to be exceeded at a lower speed than that of the shaftlines.

In order to utilize the full power potential for both shaftlines and propulsion pods, and to estimate the top speed attainable for the stock contra-rotating propulsion design on the HSS HCRSP, a F:A propeller RPM ratio must be determined so that the load-sharing ratio between the forward and aft propellers is 2.0, equivalent to that of the installed propulsion power ratio. Interpolation of the high speed results between the model-tests conducted at F:A propeller RPM ratios of 1.025 and 1.05, indicates that a F:A propeller RPM ratio equivalent to 1.032 would yield a load-sharing ratio between the forward and aft propellers of 2.0 near the full power capacities of both the shaftline and pod motors.

Estimates of the forward and aft propeller revolution rates, at the determined F:A propeller RPM ratio of 1.032, for the shaftline and pod motor power full rated capacities (50 MW and 25 MW, respectively), yields an estimated top speed attainable of 39.2 knots, as presented in Table 6. Calculations performed during the contra-rotating propulsor design predict that the 39-knot target speed should be achieved without significant thrust breakdown [Ref 8].

Table 6. HSS HCRSP estimated top speed attainable at shaftline and pod motor rated capacities (50 MW and 25 MW, respectively)

F:A Propeller RPM Ratio = 1.032							
Speed	Total Power		Fwd/shaft		Aft/shaft		Load Ratio
Kts	hP	MW	RPM	MW	RPM	MW	
39	195318	145.6	111.6	48.5	108.1	24.3	2.00
39.2	201180	150.0	112.6	50.0	109.0	25.0	2.00
40	226770	169.1	116.7	56.2	113.0	28.3	2.00

Pod Steering

The azimuthing pod units can provide lateral force in any direction, and will thus be used for steering on the HSS HCRSP, in lieu of traditional rudders. A decrease in propulsion efficiency (i.e. an increase in delivered power requirement) is to be expected with the pods rotated to any steering angle. Pod steering angles are defined as both pods LE rotated in the equivalent direction. The current HCRSP model tests were conducted with LE rotations to starboard, with

steering angles reported as relative to the design pod alignment angle of 1° LE inboard (in line with forward propeller shaftlines).

Resultant HCRSP powering for pod steering angles of 5° and 2.5° LE outboard, respectively, are presented in Tables A18 and A19. On average across the entire speed range, the total delivered power increased 7.5% and 14.2% for the 2.5° and 5° pod rotations, respectively.

However, there is no current data available to determine the pod steering angles that would be required for such a notional HSS ship. The required pod steering angles might be much smaller than the tested 2.5 degrees. Furthermore, an subsequent iteration of the podded hull design could include a reduction of the length and area of the centerline skeg, and the addition of a small, single spade rudder aft of the pods. This small rudder could be used for high speed steering with little loss of propulsion efficiency.

Pod Alignment

The HSS HCRSP was designed with the propulsion pods rotated one degree inboard to better align the aft propellers with the flow of the shaftline propellers. Variations in pod alignment were investigated in the current model test series, in order to verify that the design alignment angle (equivalent shaftlines and pods) was optimal. Pod alignment angles are defined as both pods rotated either LE inboard or LE outboard (mirrored angle relative to each other, port and starboard), with alignment angle reported as relative to the design pod alignment angle of 1° LE inboard (in line with forward propeller shaftlines).

Pod alignment of both 2.5° LE inboard and LE outboard, and 5° LE outboard, were tested on Model 5653-3A. Resultant HCRSP powering for pod alignment angles are presented in Appendix A, Tables A20-22. The three tested alignments angles all exhibited total delivered powers higher than that of the equivalent shaftlines and pods alignment, verifying that the overall best performance was achieved with the pods aligned to the shaft angles.

Stern Flap Effects

The decision was made by the HWG to conduct the fully appended experiments on Model 5653-3A with the installation of a stern flap. The stern flap utilized was that selected as the stern flap design for the JHSS BSS, Model 5653-3 [Ref. 2]. All aforementioned powering predictions included the installation of the stern flap.

In order to determine the powering effect of the stern flap, a powering test with the stern flap removed was conducted on Model 5653-3A, and is presented in Table A23. Comparison between with and without stern flap powering tests indicated that the flap effected an average delivered power reduction across the speed range of 5.6%, and at the 39-knot design speed reduced the delivered power by 4.7%.

Simulated Twin-Screw Powering (Pods Removed)

A powering experiment was conducted for the HSS in a simulated twin-screw configuration (with propulsion pods removed), using singularly the forward propellers of the contra-rotating pairs, the results of which is presented in Table A24a. The forward propellers of a contra-rotating pair are ill-suited for single rotation propulsion, and the performance of the HSS hullform in the twin-screw configuration reflected this reality. Therefore, all that was considered as useful from this test was the measured thrust and thrust deduction.

In order to estimate a more plausible twin-screw powering for the HSS, the open water propeller characteristics from a more suitable single-rotation set of propellers were utilized with the model-scale thrust deduction from the twin-screw powering test, and averaged interaction coefficients based on values determined previously from the JHSS BSS 4-screw stock propeller experiments, [Ref. 2]. In addition, the resistance associated with twin rudders, required for the

twin-screw arrangement, were included. A single rotation, high-speed, high-power propeller has been designed for 4-screw propulsion, as part of the ongoing Sealift R&D program. Open water characteristics were estimated for a modified version of this propeller design suitable for twin-screw propulsion at lower speeds, and then utilized for the HSS twin-screw powering estimate. An estimate for the top speed attainable, for such a twin-screw, single rotation propulsion arrangement, would be in the range of 35 knots. At this speed it is not expected that excessive thrust breakdown would result in erosion damage on the propellers or loss of performance. Resultant powering data for the simulated twin-screw propulsion is presented in Table A24b.

Model Test Uncertainties

Measurement uncertainties were determined on HSS HCRSP Model 5653-3A for the quantities of model speed, and hull resistance, and for combined forward shaft and aft pod quantities of thrust, torque, and rotational speed (RPM), at ship speeds of 25 and 39 knots, presented in Appendix A, Table A32. Overall uncertainties were determined by combining bias and precision limits using the root-sum-square (RSS) method for a 95 percent confidence level. The values for torque and RPM were then used to determine the uncertainty in the calculation of delivered power. The determined uncertainties for measured model delivered power reflect the combined measurement uncertainties of eight model quantities, shaft and pod torque and RPM, for each of the four propellers, and also, for this particular model-scale application, reflects the propeller RPM variability in the electronic shaft and pod synchronization.

Resistance measurement uncertainties, at 25 and 39 knots, were determined to be $\pm$1.12% and $\pm$0.79% of the measured nominal mean values, respectively. Likewise, the model scale delivered power measurement uncertainties were $\pm$4.16% and $\pm$3.86%, at 25 and 39 knots.

WAVE TRACES

Wave traces along the hull surface of HCRSP Model 5653-3A were drawn between the forward (FP) and aft (AP) perpendiculars, DES displacement, 39 knot ship speed, for both the towed and powered conditions. Resultant wave trace heights on the hull surface are presented in Figure A6. Differences in the wave traces between towed and powered conditions were negligible between the bow and ship station 10. Aft of station 10, differences remained minimal.

A comparison was made between the traces along the hull surface of HCRSP Model 5653-3A versus the BSS Model 5653-3, presented in Figure A7. Unfortunately, the experiments on the two different hull candidates were conducted at slightly different speeds.

SEALIFT CONCEPTS COMPARISONS

HSS HCRSP versus JHSS 4-Screw

The current Hybrid Contra-Rotating Shaft-Pod (HCRSP) experiments were conducted on the 977 ft notional High Speed Sealift (HSS) monohull parent platform, as represented by Model 5653-3A. This parent hullform is the same as that used previously for the Joint High Speed Sealift (JHSS) Baseline Shaft & Strut (BSS) conventional 4-screw open shafts and struts configuration. Resistance and stock open propeller powering experiments were conducted on the JHSS BSS [Ref 2].

Resistance and stock open propeller powering experiments were conducted on the JHSS BSS [Ref 2], and are compared herein to the present experiments on the HSS HCRSP. Both sealift hullforms were tested at the equivalent design (DES) displacement. Comparisons are presented in Appendix A, Figure A5 and Table A33, and in Table 7.

For the HSS HCRSP configuration, the removal of two of the four sets of propulsion shafts and struts, and the addition of the two tractor propulsion pods, exhibited an average resistance reduction of 2.9% across the speed range, relative to the 4-screw JHSS BSS. As aforementioned,

it is speculated that the presence of the forward propeller shaftlines directly in front of the propulsion pods reduced the effective resistance of the pods. At the 39-knot design speed, the resistance reduction of the HCRSP was 0.8% relative to the BSS.

For the powering comparison, the HSS HCRSP 'actual capability' at varying F:A RPM ratios (data from Table 5) was utilized, relative to that of the JHSS BSS. The HSS HCRSP exhibited an average 16.3% reduction in total delivered power requirement across the speed range of 15 to 39 knots, relative to the JHSS BSS, at DES displacement. At the 39-knot design objective speed, the delivered power reduction of was 10.2%. It was to be expected that the HCRSP would exhibit a significant increase in the propulsive coefficient, ηD, relative to that of the BSS, owing to a substantial increase in the efficiency of the contra-rotating propulsion configuration relative to the single rotation propellers. This increase in efficiency, coupled with the reduction in resistance, resulted in the substantial reduction in total delivered power for the HSS HCRSP relative to the JHSS BSS.

Table 7. Comparison between High Speed Sealift (HSS) Hybrid Contra-Rotating Shaft-Pod (HCRSP) and Joint High Speed Sealift (JHSS) Baseline Shaft & Strut (BSS)

HSS HCRSP Comparison to JHSS BSS								
	JHSS BSS			HSS HCRSP*			HCRSP vs. BSS	
VS (kts)	PE (hP)	PD (hP)	ηD	PE (hP)	PD (hP)	ηD	PE	PD
25	31987	50426	0.634	30726	41614	0.738	-3.9%	-17.5%
36	96351	149593	0.644	94100	130211	0.723	-2.3%	-13.0%
39	141663	217339	0.652	140564	195123	0.720	-0.8%	-10.2%

*Actual Capability w/varied F:A RPM ratios

With the addition of pods to the parent hull platform, there is a significant increase in lateral area aft. A final iteration of the podded hull design might include a reduction in the length and area of the centerline skeg. This reduced-size skeg would further reduce the effective power of the podded hullform relative to the parent hullform.

An assessment was made of the effects on powering for the HCRSP hull, under simulated possible steering conditions, where the pods yaw angles were varied. This showed a loss of propulsion efficiency and a consequential increase in required power-at-speed. Currently, there is no data on the conventional BSS 4-screw configuration for assessing the impact of rudder deflections on powering performance, however, a similar loss of efficiency would be expected.

During the current HSS HCRSP experiments, a series of appendage stripping tests were conducted. Within this series were a pair of tests with the HSS configured in a twin-screw propulsion arrangement (twin open propeller shaftlines installed and pods removed), and then a subsequent test with the shaftlines removed. A prediction of the twin shaftline resistance, and equivalent resistance per shaft, can be determined from the comparison between these two tests, presented in Appendix A, Table A34. Similarly, an appendage stripping series of experiments was conducted during the JHSS BSS stock open propeller powering experiments [Ref 2]. A prediction of the four shaftline resistance, and equivalent resistance per shaft, from the JHSS BSS tests, are also presented and compared to that of the HSS in Table A34.

The resultant shaftline resistances, from the 4-screw JHSS BSS and the twin-screw HSS, when compared on the basis of resistance/shaft, compare extremely favorably. Expressed as a percentage of bare hull effective power, the per shaft increase in resistance ranged from approximately 8% at low speed to 3% at high speed, with an average increase in resistance of 6.1% over the entire speed range.

HSS HCRSP versus Simulated 2-Screw

A powering experiment was conducted for the HSS in a simulated twin-screw configuration (with propulsion pods removed), using singularly the forward propellers of the contra-rotating pairs. Utilizing the results of this 2-screw test, along with the open water propeller characteristics from a more suitable single-rotation set of propellers, averaged interaction coefficients based on values determined previously from the JHSS BSS 4-screw stock propeller experiments, [Ref. 2], and added resistance associated with twin rudders, resulted in a more plausible estimate of simulated twin-screw powering for the HSS, presented in Table A35. Again, for the powering comparison, the HSS HCRSP 'actual capability' at varying F:A RPM ratios (data from Table 5) was utilized, relative to that of the simulated twin-screw powering.

Table 8. Comparison between High Speed Sealift (HSS) Hybrid Contra-Rotating Shaft-Pod (HCRSP) and HSS Simulated Twin-Screw

HSS HCRSP vs. Simulated HSS Twin-Screw								
	HSS Simulated Twin-Screw			HSS HCRSP			HCRSP vs. 2-Screw	
VS (kts)	PE (hP)	PD (hP)	ηD	PE (hP)	PD (hP)	ηD	PE	PD
25	27799	46902.6	0.595	30726	41614	0.738	+10.5%	-11.3%
36	88052	142399	0.620	94100	130211	0.723	+6.9%	-8.6%
39	130256	205829	0.675	140564	195123	0.720	+7.9%	-5.2%
	39 knots exceeds the cavitation limit for twin-screw			Actual Capability w/varied F:A RPM ratios				

The HCRSP propulsion arrangement, essentially the placement of two propulsion pods behind the shaftlines of a notional twin-screw, single-rotation high-speed sealift hullform, despite a significant increase in resistance, the formation of two pairs of contra-rotating propellers results in a net reduction in required delivered power at all speeds above 15 knots. Although a powering comparison is not valid at the 39-knot design speed (due to cavitation limitations of the twin-screw propulsion), the HCRSP arrangement reduced the powering relative to twin-screw by 6.9% at the threshold speed of 36 knots, and an average of 10.4% over the speed range of 15-36 knots.

CONCLUSIONS

The tested High Speed Sealift (HSS) Hybrid Contra-Rotating Shaft-Pod (HCRSP) concept propulsion system consists of two pairs of azimuthing, tractor-type (with propellers installed forward of the pod body) propulsion pods, arranged directly behind conventional open propellers which are supported by open shaftlines and struts. Each pair of propellers, the forward one on the shaftline and the aft one in front of the pod, form a contra-rotating pair of propellers. This propulsion system was installed on Model 5653-3A. A stock contra-rotating propulsor was designed and manufactured for the present tests on the HSS HCRSP.

Resistance tests to define displacement effects and the resistance contribution of the propulsion appendages were conducted. A total of sixteen different HCRSP powering conditions were tested on HSS Model 5653-3A, including variations in ship displacement, pod alignment, pod steering, and forward-to-aft propeller RPM ratios.

When at the selected forward-to-aft propeller RPM ratio of 1:1, design (DES) displacement, it is predicted that the HSS HCRSP will require a total delivered power, shafts and pods, of 196,111 hP (146.2 MW), at a propeller rotational speed of 110.4 RPM (both forward and aft propellers) to attain the 39-knot design speed. For the forward propellers, the predicted power/shaft is 46.5 MW, while the predicted power for each pod-driven aft propeller is 26.7 MW (in excess of the rated full power capacity of the pod motors).

Model tests indicated that increasing the load on the forward propellers reduced the required total delivered power in the lower portion of the speed range, while conversely, increasing the load on the aft pod propellers reduced the required total delivered power in the upper portion of the speed range. However, on average across the entire speed range, the delivered power exhibited by all five tested propeller RPM / load ratios did not differ by more than $\pm$1%.

Estimates of the forward and aft propeller revolution rates, at the determined F:A propeller RPM ratio of 1.032 required to utilize the shaftline and pod motor power full rated capacities (50 MW and 25 MW, respectively), yields an estimated attainable top speed of 39.2 knots for the HSS HCRSP.

At the 39-knot design speed, the HSS HCRSP exhibited 10.2% reduction in total delivered power requirement relative to the JHSS BSS, at DES displacement. Average reduction in delivered power over the speed range of 15 to 39 knots, for the HSS HCRSP relative to JHSS BSS, was 16.3%. An increase in propulsion efficiency of the contra-rotating propulsion configuration relative to the single rotation propellers, coupled with a reduction in resistance of the two shaft-pod pairs relative to the 4-screw shaftlines, resulted in the substantial reduction in total delivered power for the HSS HCRSP relative to the JHSS BSS.

Relative to a simulated twin-screw configuration, the HCRSP exhibited a reduced powering relative to twin-screw of 6.9% at the threshold speed of 36 knots, and an average of 10.4% over the speed range of 15-36 knots.

CONTINUATION OF PROGRAM

Several additional phases of work are planned for the evaluation of hybrid pod propulsion on the High Speed Sealift (HSS).

(1) Design contra-rotating propulsor tests on the HSS Hybrid Contra-Rotating Shaft-Pod configuration. A contra-rotating propulsor specifically designed and tailored for this application, which will utilized knowledge gained from the present model-scale experiments, is expected to realize even better propulsion efficiency than the present stock propulsor design.

(2) Pod and propeller cavitation testing, evaluation, and assessment is to be conducted on the hybrid contra-rotating shaft-pod propulsion system.

(3) Evaluation of a HSS Hybrid Contra-Rotating Dual-Pod configuration, a concept where both the forward and aft propellers in a contra-rotating pair are powered by propulsion pods. The aft propeller would remain on a COTS 25 MW tractor pod, whereas the forward propeller would be powered by a fixed (non-azimuthing) pusher-type pod, of a much larger size and length able to accommodate a propulsion motor set equivalent to 50 MW (comprised of two 25 MW commercial motors in tandem).

RECOMMENDATIONS

(1) The performance of the Hybrid Contra-Rotating Shaft-Pod propulsion system tested on the notional 977 ft High Speed Sealift hull platform has shown that this promising energy savings device warrants additional investigation, and should be considered for future Naval ship applications involving high speed vessels. Current model-tests have shown that commercial claims of 15% reduction in power with a hybrid pod contra-rotating propulsion system are in the realm of possible performance improvements for Naval vessels. This substantial performance improvement could lead to tremendous fuel savings potential in not only new ship designs but also as a retrofit device to existing ships which could meet the criteria for the installation of such and energy enhancement device. Both such avenues for design on Naval vessels should be pursued.

(2) A brief series of model-scale powering experiments should be conducted on the conventional 4-screw baseline shaft & strut (BSS) configuration to determine the impact of rudder deflections on the propulsion efficiency and required delivered power for such a hullform.

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APPENDIX A

Resistance & Powering Data and Analysis

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FIGURES OF APPENDIX A

TABLES OF APPENDIX A

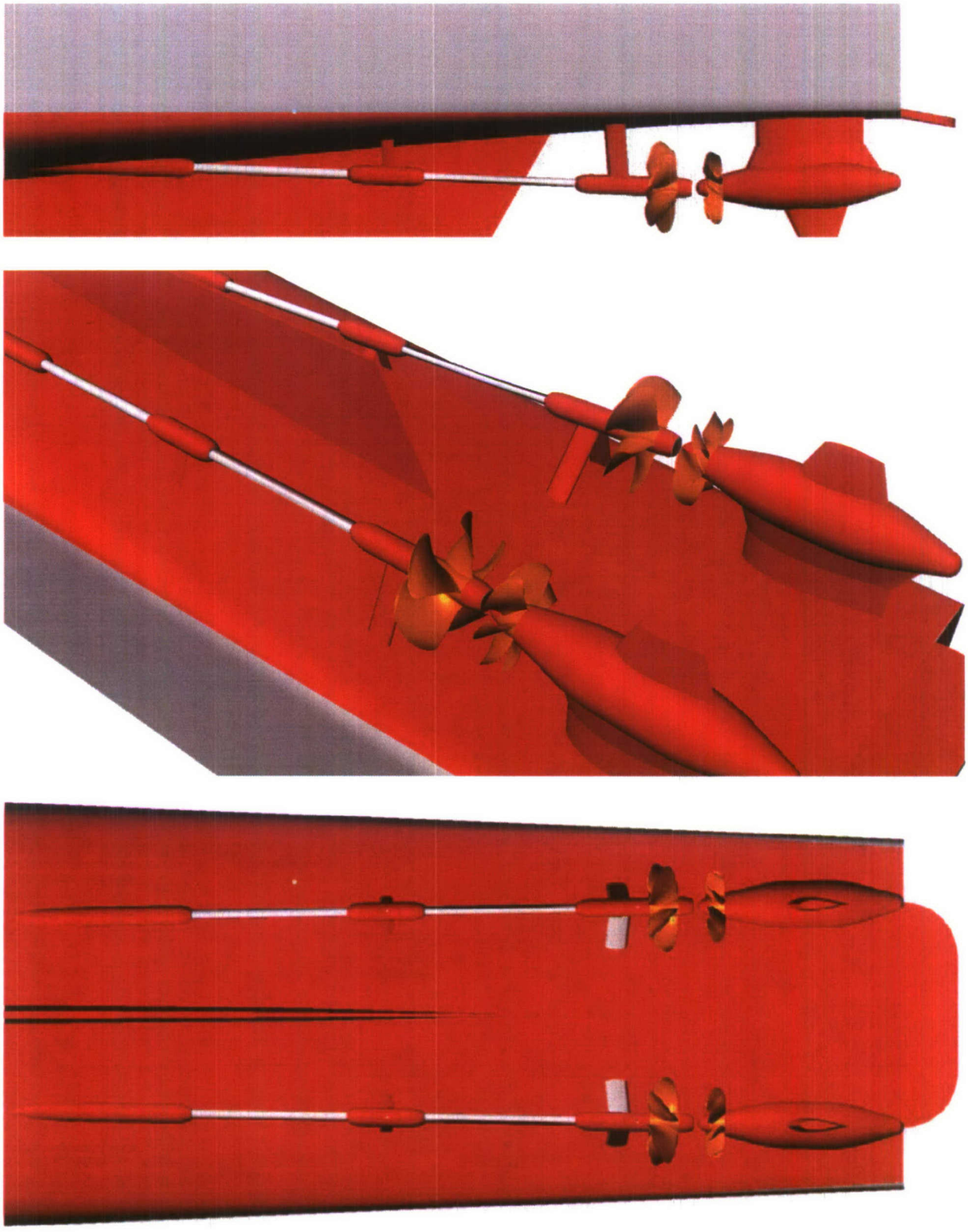


Fig. A1. Hybrid Contra-Rotating Shaft-Pod (HCRSP), computer renderings of concept

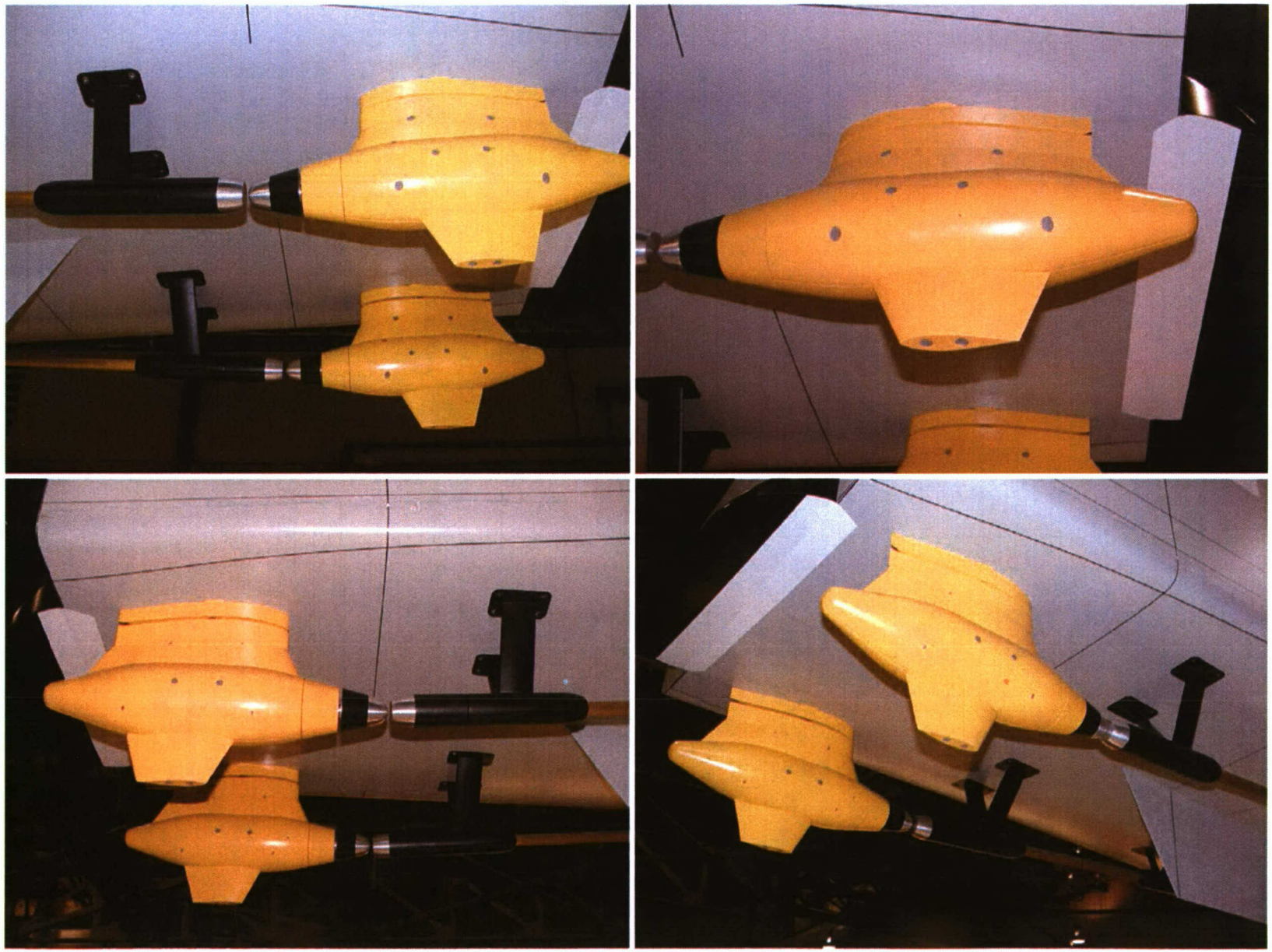


Fig. A2. HSS HCRSP Model 5653-3A and CR model propellers 5513-14-15-16

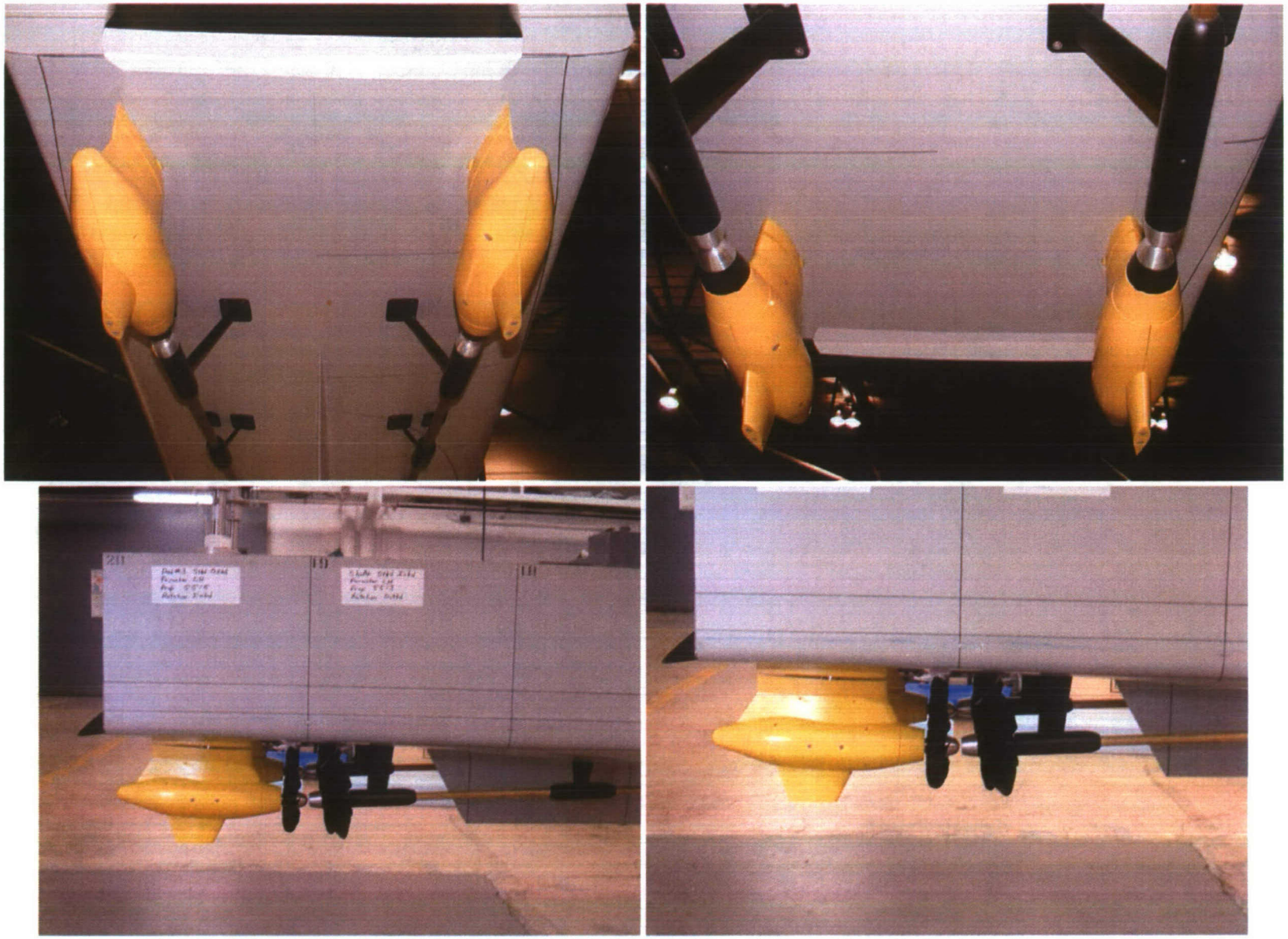


Fig. A2. HSS HCRSP HSS HCRSP Model 5653-3A and CR model propellers 5513-14-15-16 - continued

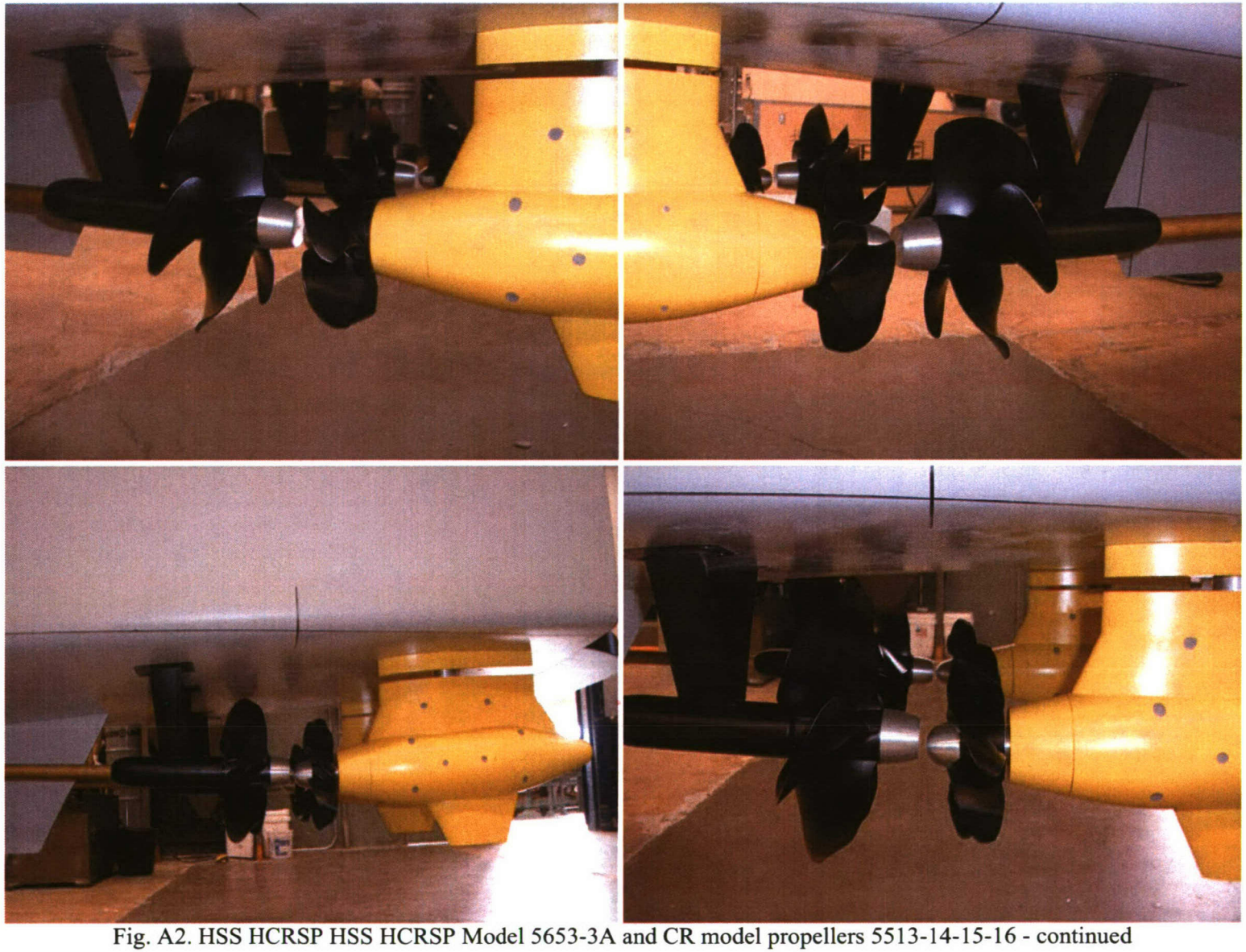
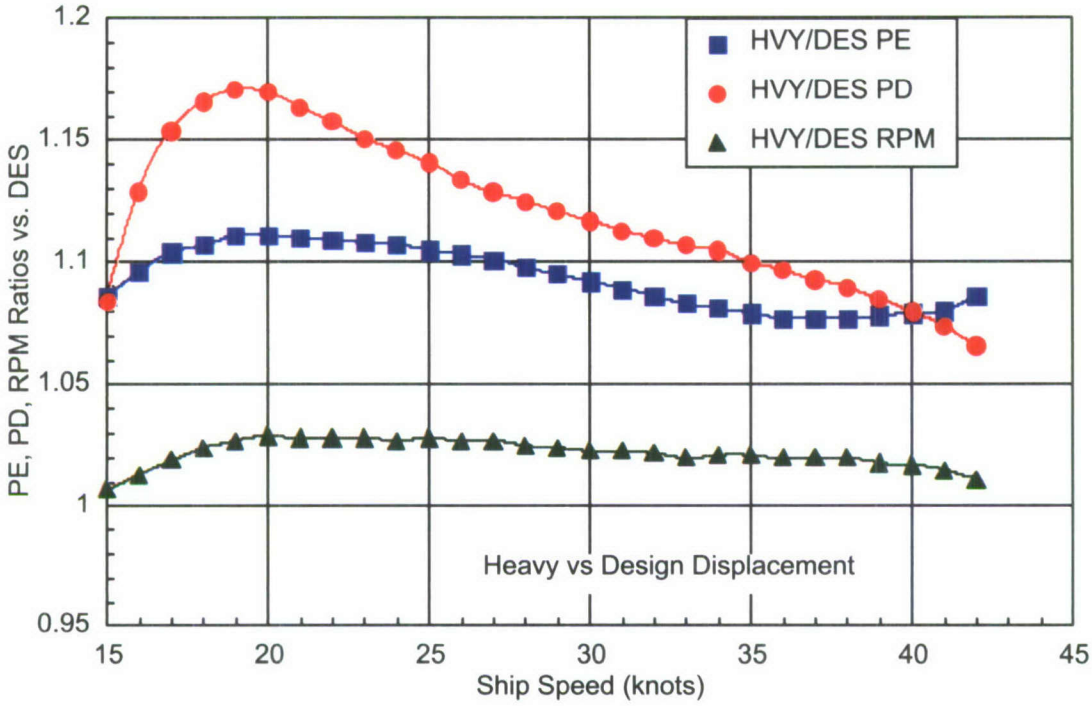


Fig. A2. HSS HCRSP HSS HCRSP Model 5653-3A and CR model propellers 5513-14-15-16 - continued



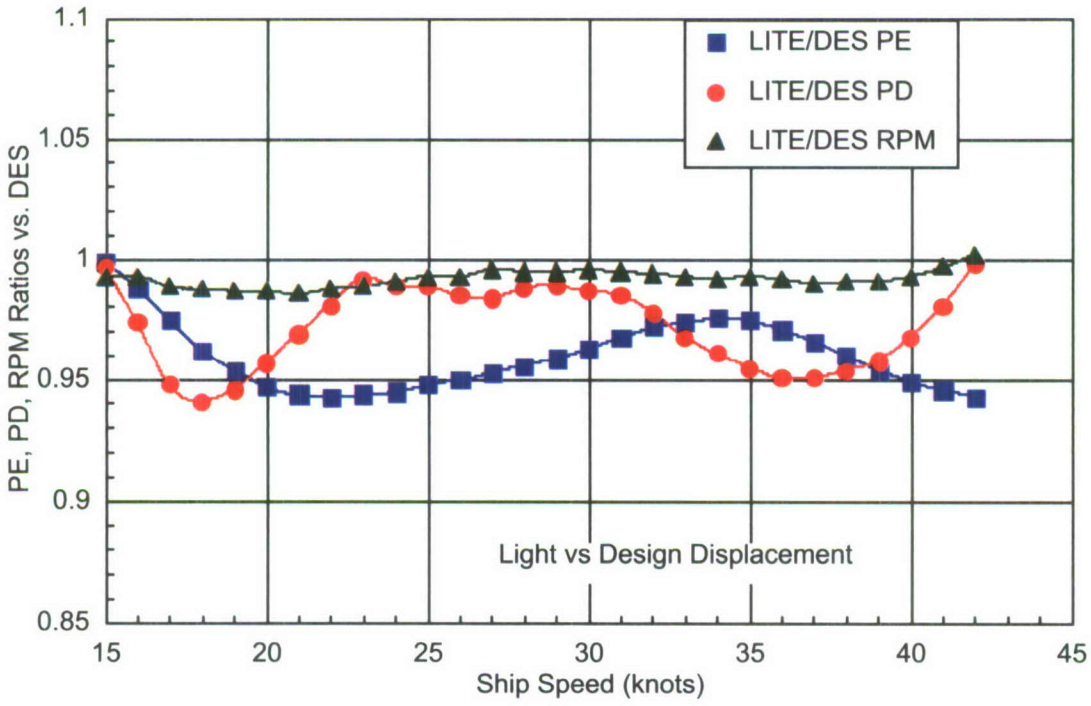
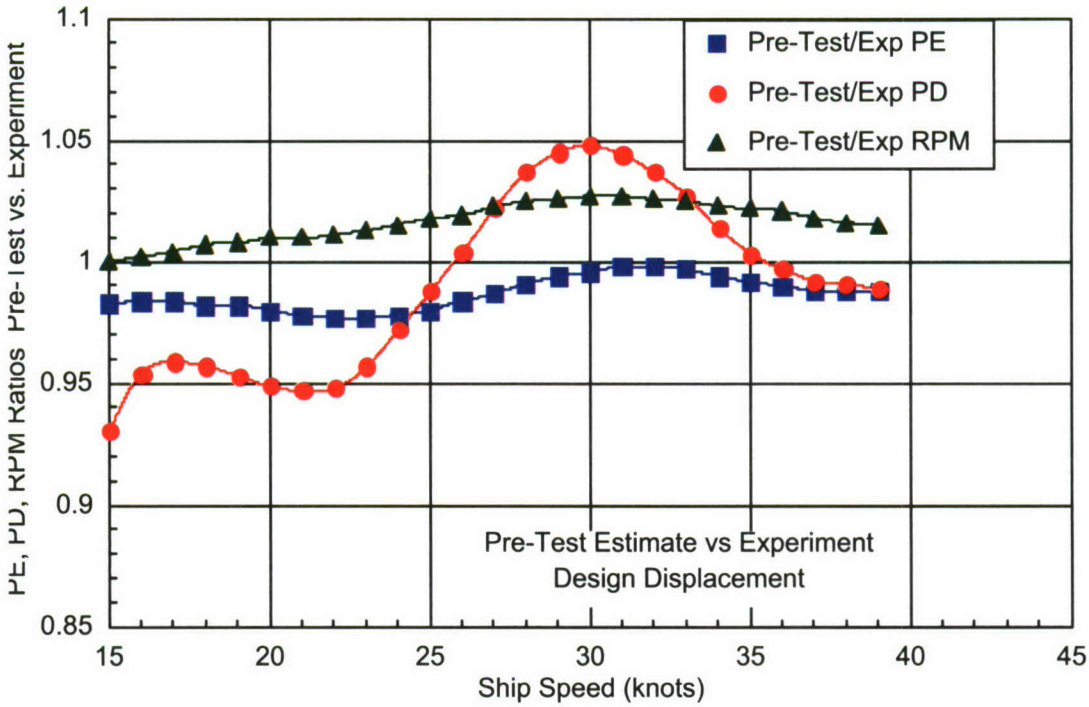


Fig. A3. HSS HCRSP comparisons between tested propulsion configurations



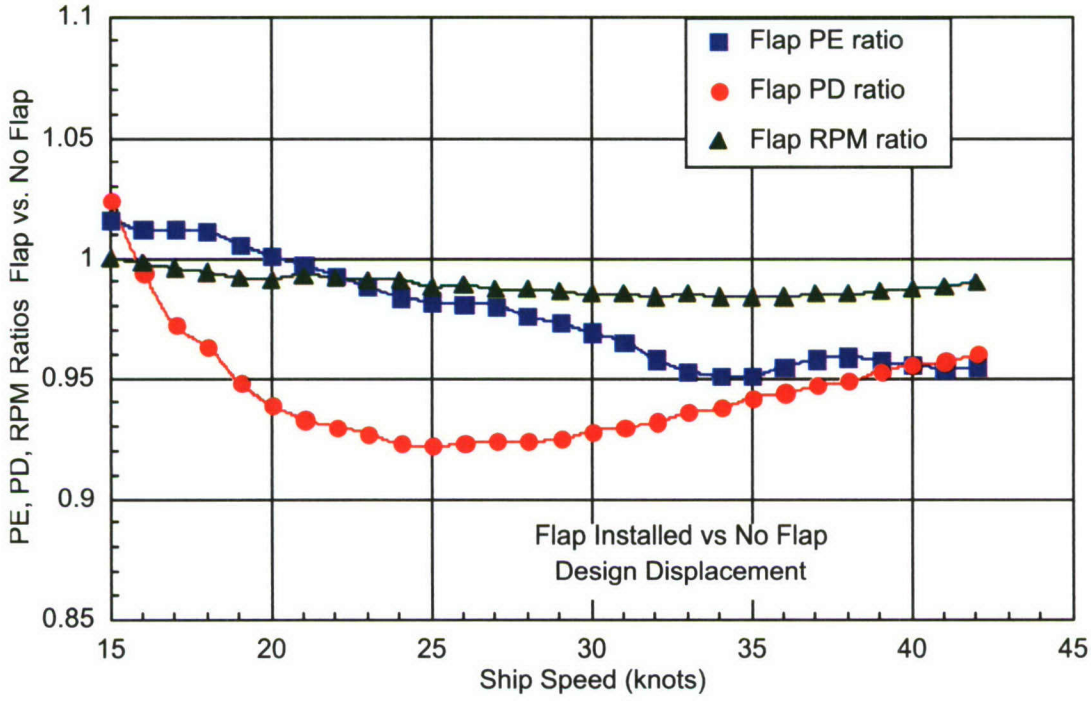
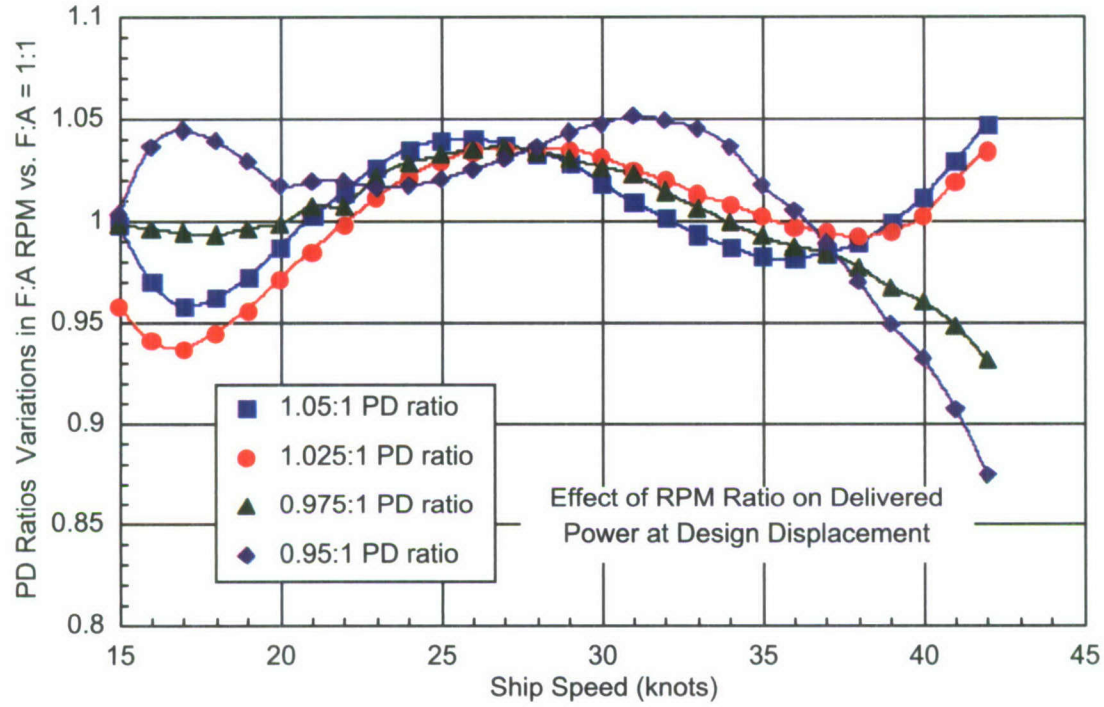


Fig. A3. HSS HCRSP comparisons between tested propulsion configurations - continued



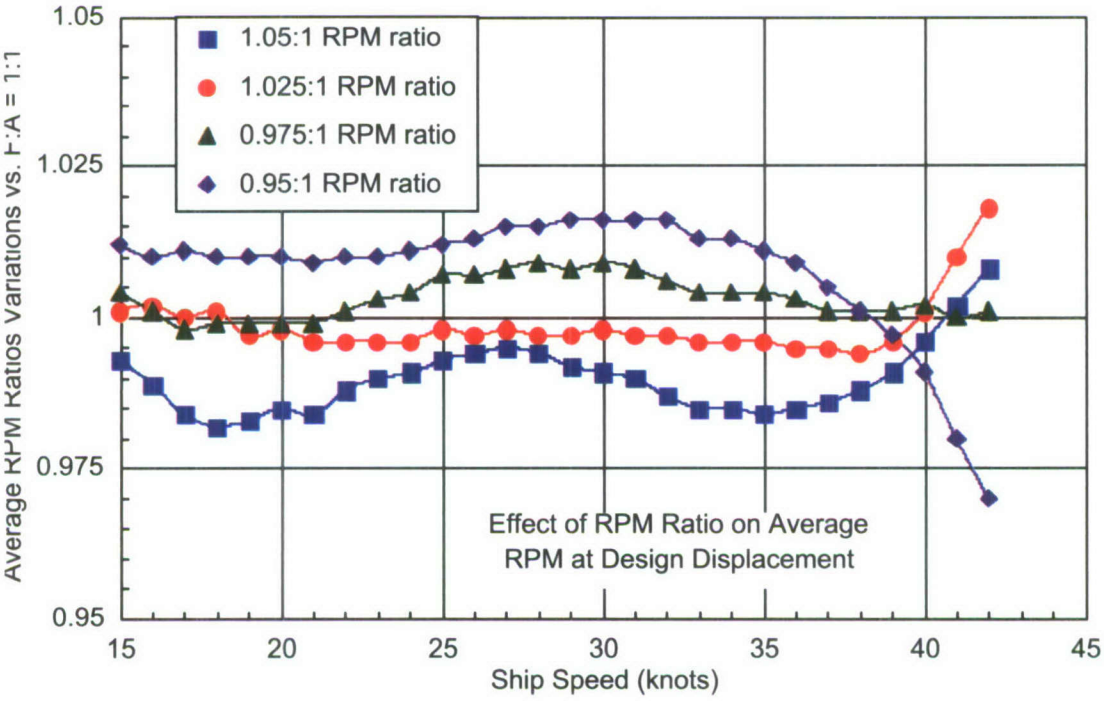
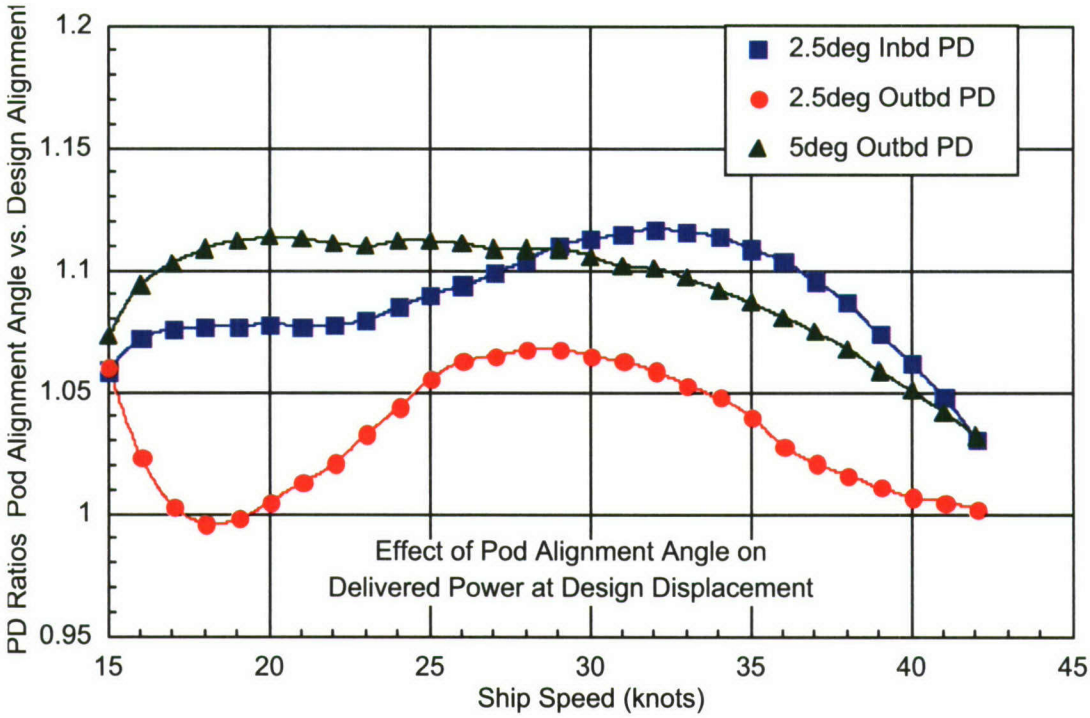


Fig. A3. HSS HCRSP comparisons between tested propulsion configurations - continued



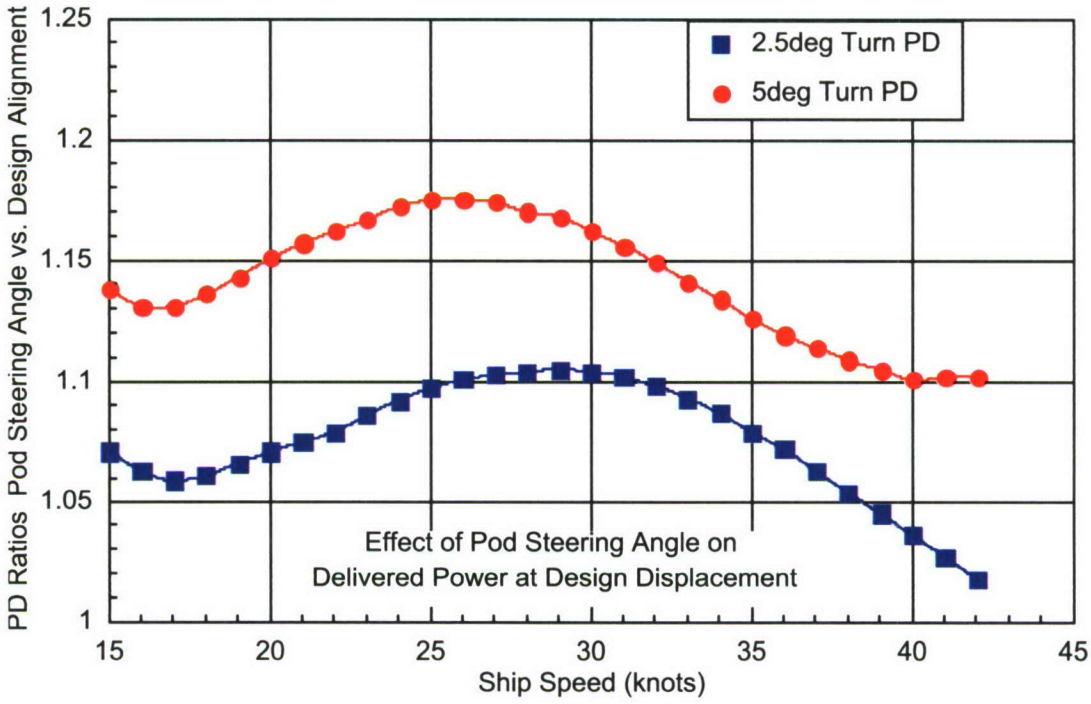


Fig. A3. HSS HCRSP comparisons between tested propulsion configurations – continued

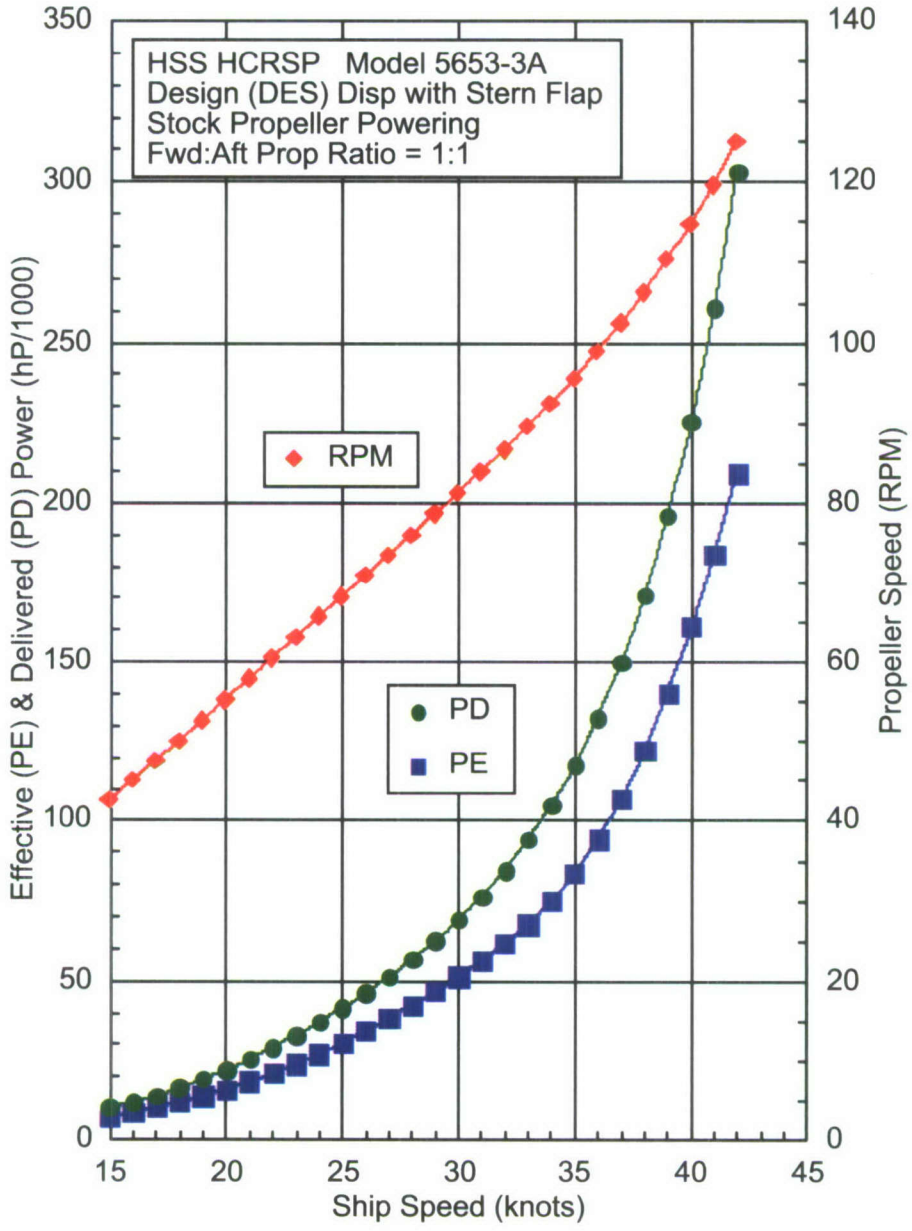


Fig. A4. HSS HCRSP Powering Prediction, Exp76, Fully Appended, DES Displacement, F:A RPM = 1:1

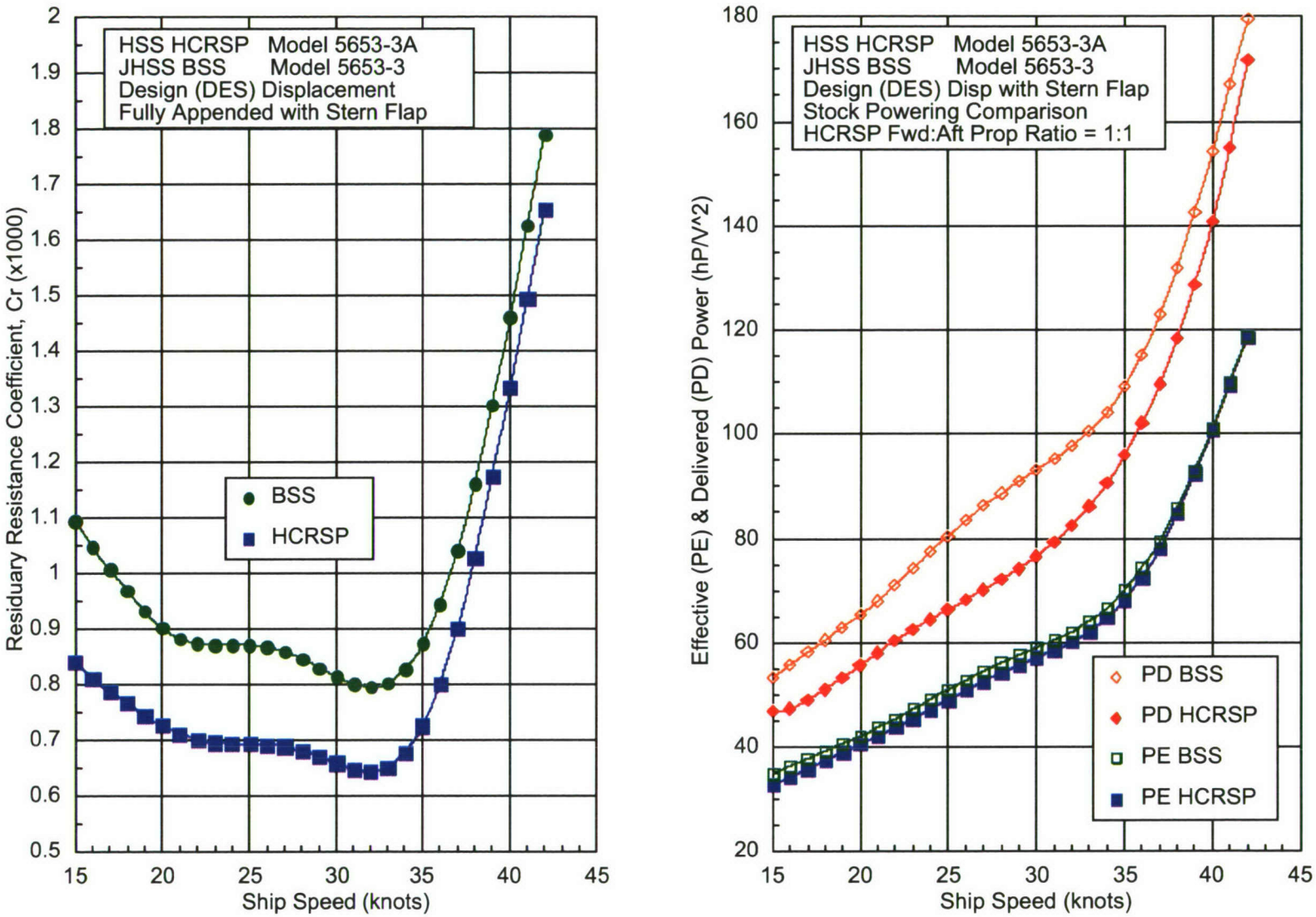
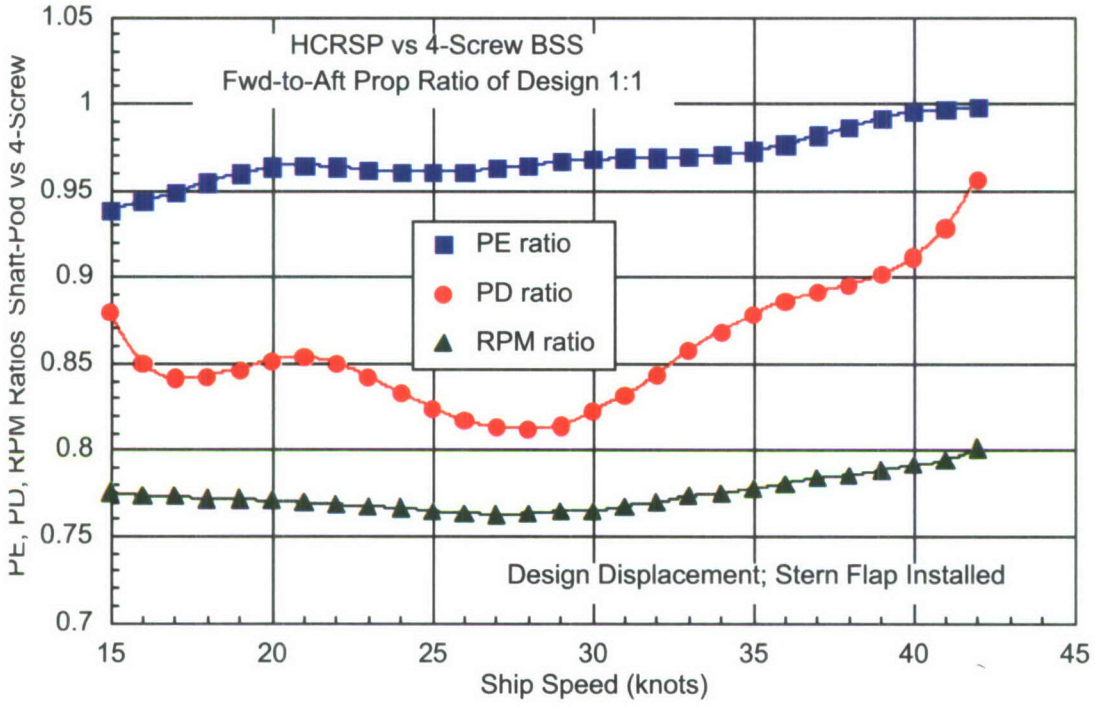


Fig. A5. Resistance and Powering Comparisons, HSS HCRSP versus JHSS BSS (4-Screw Open Propeller), DES Displacement



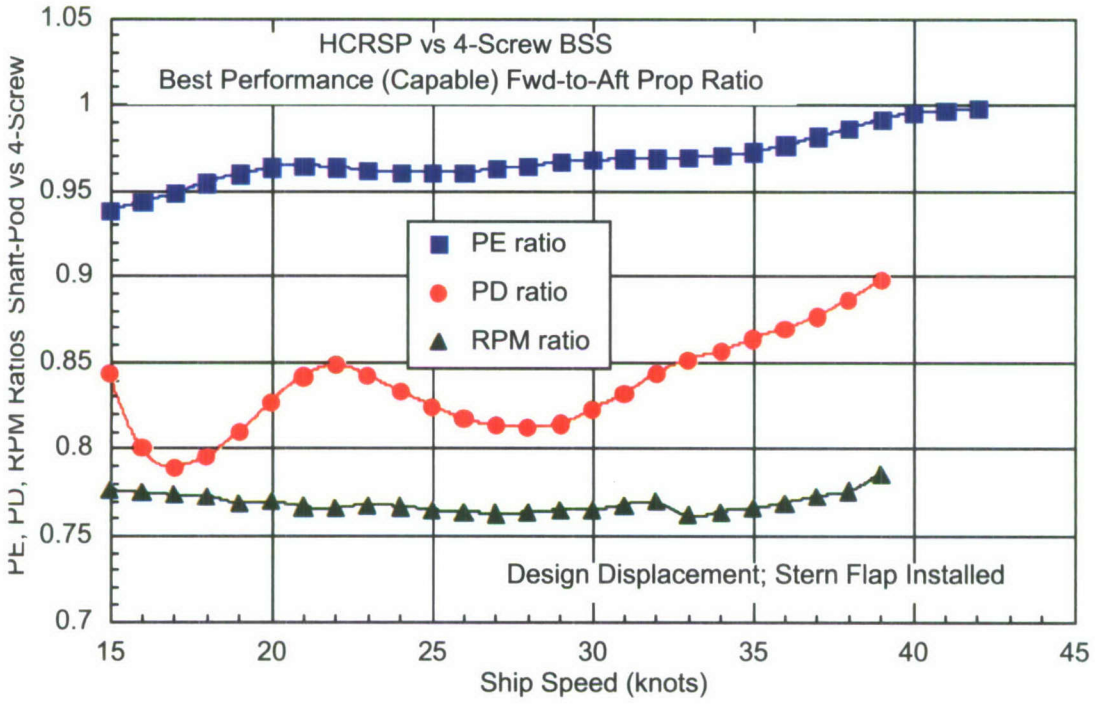


Fig. A5. Resistance and Powering Comparisons, HSS HCRSP versus JHSS BSS (4-Screw Open Propeller), DES Displacement - continued

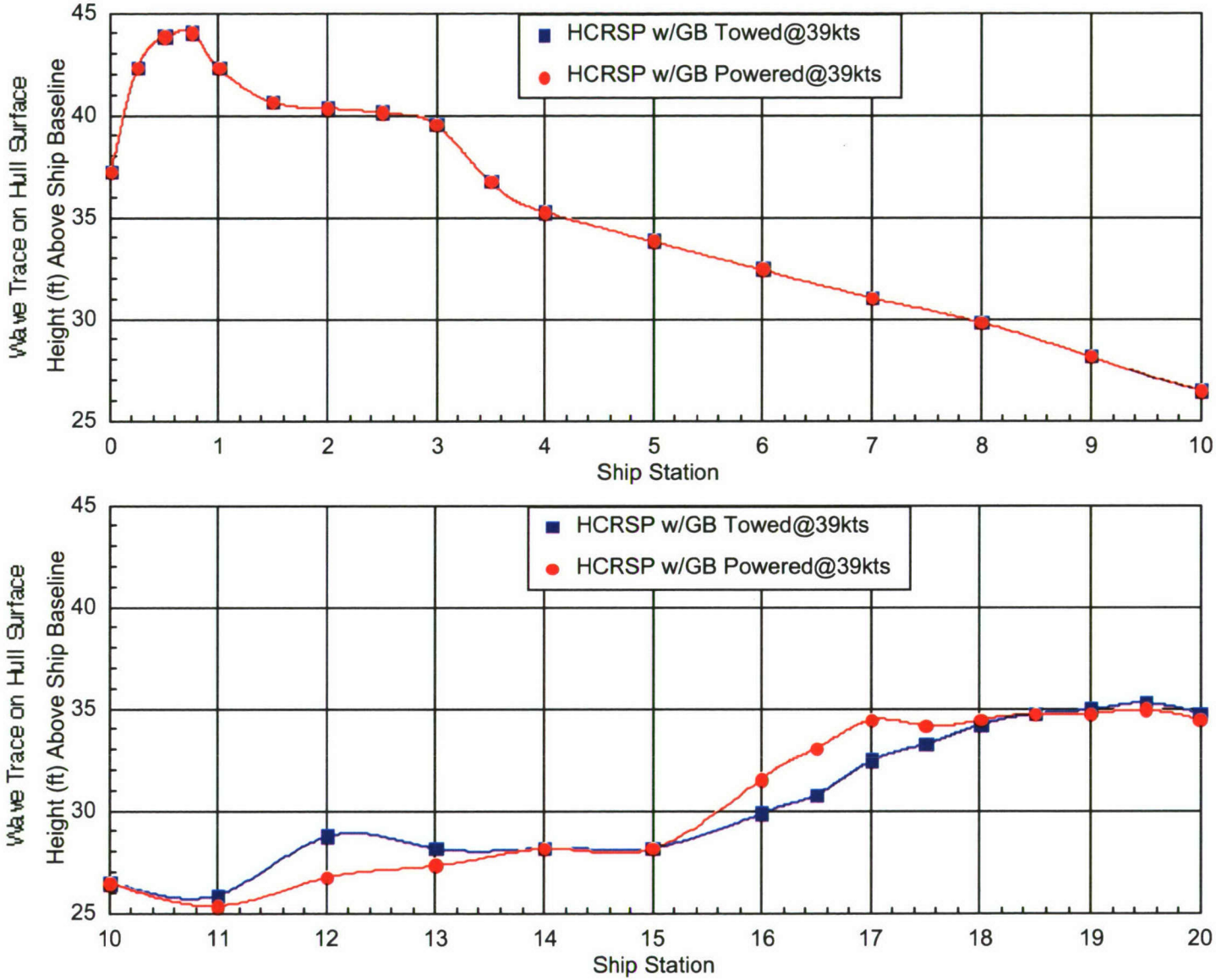


Fig. A6. HSS HCRSP Wave Traces on Hull Surface, towed and powered, 39 knots

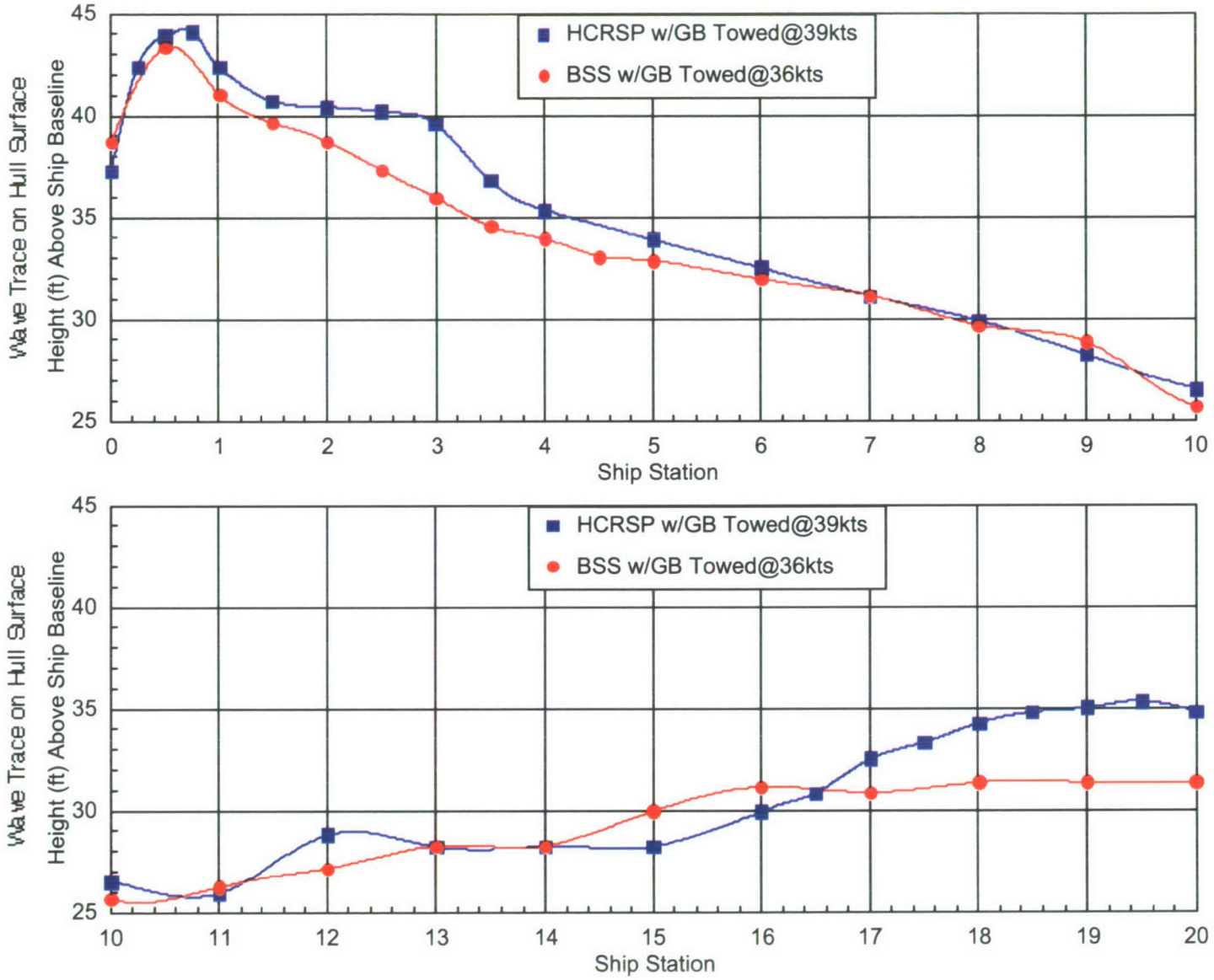


Fig. A7. Wave Traces on Hull Surface, comparison of HSS HCRSP versus JHSS BSS

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Table A1. HSS HCRSP Model 5653-3A Test Agenda

Date	Test #	Test Type	Loading	Appendage Configuration [1]	Propellers	Fwd:Aft RPM	Speeds (knots)	Comments
1/14/08	-	Move model to Carriage 2 drydock. Install/Align Pods. Ballast model for 3 displacements. Install model, hardware, software, electronics on						
1/15/08		Carriage. Mechanical system, electronics, data acquisition softwear troubleshooting.						
	70	Alignment (PE)	HVY	Fully Appended [1-6]	n/a		36	
1/16/08	71	Resistance, PE					15-45	HVY Resistance
	~~72~~	Powering, PD			Stock Hybrid C-R[2]	1:1	PD seven[3]	aborted
	73							HVY Powering (RPMs set manually)
	-	Weights (orange marked) Removed. Ballasted for DES displacement.						
1/17/08	~~74~~	Troubleshooting	DES	Fully Appended [1-6]	n/a		0	Troubleshooting of Shaft&Pods RPM ballancing.
	75	Resistance, PE					15-45	DES Resistance, including: dedicated Photo runs.
	76	Powering, PD			Stock Hybrid C-R	1:1	PD seven	DES Powering, including: uncertainty, dedicated Photo runs.
1/18/08	77	Resistance, PE			n/a		39	Check Test for Test 75, uncertainty data
	78	Powering, PD			Stock Hybrid C-R	1:1	PD seven	Design Powering (76 cont), over-and-underpowered
	79	Fwd:Aft Prop Ratio				1.05:1		FWD:AFT propeller RPM 1.05:1
1/22/08	80	Variations, PD				0.95:1		FWD:AFT propeller RPM 0.95:1
	81					0.975:1		F:A prop RPM 0.975:1 (seeking minimum power)
	82					1.025:1		F:A prop RPM 1.025:1 (attempting F:A PD Ratio 2:1)
1/23/08	~~83~~	Pods in Turn, PD		*Pods Rotated in Unison*		1:1		aborted
	84							Simulated turn, both Pods 5° to Port
	85							Simulated turn, both Pods 2.5° to Port
	-	Wave Traces					39	Resistance (black) and Powered (red)
1/24/08	86	Pod Alignment PD		*Pods Rotated Opposite Directions*			PD seven	Pods Aligned/Rotated LE 2.5° Inbd
	87							Pods Aligned/Rotated LE 2.5° Outbd
	88							Pods Aligned/Rotated LE 5° Outbd
	89	Pod Bearing Forces					15-36	Pods at 30degOutbd angle. Powered, speeds up to max X & Y gages force capacities on model pods
	90						15-30	Pods at 60degOutbd angle. "
	91						15-25	Pods at 90degOutbd angle. "
1/25/08	-	Weights (lavender marked) Removed. Ballasted for LITE displacement.						
	92	Resistance, PE	LITE	Fully Appended [1-6]	n/a		15-45	LITE Resistance
	93	Powering, PD			Hybrid C-R	1:1	PD seven	LITE Powering
	-	Stern Flap Removed. Weights (lavender marked) Returned. Re-ballasted for DES displacement.						
1/28/08	94	Resistance, PE	DES	[1-5]	n/a	n/a	15-45	Determine stern flap ΔPE
	95	Powering, PD		*Flap Removed*	Hybrid C-R	1:1	PD seven	Determine stern flap ΔPD
	-	Model removed from carriage and Twin Pods Removed. Equivalent ballast weight added and positioned to achieve DES displacement.						
1/29/08	-	Model reinstalled under carriage. Data acquisition reconfiguration/troubleshooting for twin-shaft. Model Alignment (PE) at 36knots.						

Table A1. HSS HCRSP Model 5653-3A Test Agenda - continued

Date	Test #	Test Type	Loading	Appendage Configuration [1]	Propellers	Fwd:Aft RPM	Speeds (knots)	Comments
1/29/08	96	Resistance, PE	DES	[1-4] *Pods Removed*	n/a		15-45	Determine twin pods ΔPE
	97	Powering, PD	DES		FWD HCR Props Only	n/a	PD seven (no 42)	Twin screw powering (no pods), up to 50MW/shaft or to Dyno limits.
	-	Model removed from carriage and Twin Shaftlines Removed. Equivalent ballast weight added and positioned to achieve DES displacement.						
1/30/08	-	Model reinstalled under carriage. Data acquisition check-out. Model Alignment (PE) at 36knots.						
	~~98~~	Resistance, PE	DES	[1-3] *S&S Removed*	n/a		15-45	aborted
	99							Determine twin shaftline ΔPE
	-	De-Rig Carriage and Model						
1/31/08	-							

Footnotes:

[1] Appendages: [1] Gooseneck Bulb; [2] Centerline Skeg; [3] Twin Bilge Keels; [4] Twin shaftlines; [5] Twin Pods; [6] Stern Flap @10°

[2] Stock Hybrid Contra-Rotating model propellers 5513 & 5514 (Fwd) and 5515 & 5516 (Aft)

[3] Seven speeds of interest for Powering Tests: 15, 20, 25, 30, 36, 39, 42

Table A2. HSS HCRSP Ship/Model Test Conditions

HCRSP w/GB	DES: 36,491 tons 2 Pods		HVY: 40,140 tons +10% 2 Pods		LITE: 32841 tons -10% 2 Pods		DES: 36,491 tons Pods Removed and/c Shaftlines Removed	
Model 5653-3A	SHIP	MODEL	SHIP	MODEL	SHIP	MODEL	SHIP	MODEL
MODEL SCALE RATIO	-	34.121	-	34.121	-	34.121	-	34.121
LOA (ft)	977.5	28.648	977.5	28.648	977.5	28.648	977.5	28.648
LBP (ft)	950.5	27.857	950.5	27.857	950.5	27.857	950.5	27.857
LWL (ft)	978.2	28.669	947.9	27.781	976.4	28.616	978.2	28.669
WET SURF HULL(sq ft)	104957	90.151	108591	93.272	97802	84.005	104957	90.151
WET SURF APP(sq ft)	6662	5.722	6662	5.722	6662	5.722	2692	2.313
TOTAL WET SURF(sq ft)	111619	95.873	115253	98.994	104464	89.727	107650	92.463
DISPLACEMENT (ton, lbs)	36491	2000	40140	2200	32841	1800	36491	2000
BOW DRAFT @FP (ft)	28.73	0.842	30.48	0.893	26.95	0.790	28.82	0.845
STERN DRAFT @AP (ft)	28.73	0.842	30.78	0.902	26.95	0.790	28.82	0.845
SHIP TRIM (+ft bow up)	0.00	0.000	0.30	0.009	0.00	0.000	0.00	0.000
TRIM ANGLE (degrees)	0.00		0.02		0.00		0.00	
TEMP (F)	59	70	59	70	59	70	59	70
RHO	1.9905	1.9362	1.9905	1.9362	1.9905	1.9362	1.9905	1.9362
NU	1.2817	1.0552	1.2817	1.0552	1.2817	1.0552	1.2817	1.0552
Bow Deck/Keel (ft)	72.5	2.124	72.5	2.124	72.5	2.124	72.5	2.124
Pos of Hook fwd of FP (ft)	37.0	1.083	0.0	0.000	0.0	0.000	37.0	1.083
Stern Deck/Keel (ft)	71.7	2.103	71.7	2.103	71.7	2.103	71.7	2.103
Pos of Hook aft of AP (ft)	11.4	0.333	0.0	0.000	0.0	0.000	11.4	0.333
BOW HOOK SETTING (ft)		1.282		1.230		1.334		1.279
Hook if at FP (ft)	-	1.282	-	1.230	-	1.334	-	1.279
Hook if at AP (ft)	-	1.261	-	1.201	-	1.313	-	1.258
STERN HOOK SETTING (ft)		1.261		1.201		1.313		1.258
SHAFT PROP DIA (ft, in)	21.50	7.560	21.50	7.560	21.50	7.560	21.50	7.560
SHAFT PROP ROTATION	OTBD	OTBD	OTBD	OTBD	OTBD	OTBD	OTBD	OTBD
POD PROP DIA (ft, in)	17.00	5.98	17.00	5.980	17.00	5.980	n/a	n/a
POD PROP ROTATION	INBD	INBD	OTBD	OTBD	OTBD	OTBD	n/a	n/a
SPEED RANGE, min (kts)	15.0	2.57	15.0	2.57	15.0	2.57	15.0	2.57
Design Speed (kts)	39.0	6.68	39.0	6.68	39.0	6.68	36.0	6.16
max (kts)	45.0	7.70	45.0	7.70	45.0	7.70	39.0	6.68
MODEL DISP desired (lbs)		2000		2200		1800		2000
DISP actual (ton, lbs)	36491	2000	40139	2200	32842	1800	36491	2000
MODEL WEIGHT (lbs)	-	1180	-	1180	-	1180	-	1096
Floating Platform (lbs)	-	45	-	45	-	45	-	45
BALLAST required (lbs)	-	775	-	975	-	575	-	859
delta DISP (ton, lbs)				+200		-200		
				+10.0%		-10.0%		
APPENDAGES, ws (sqft)	6662.3	5.722	6662.3	5.722	6662.3	5.722	2692.4	2.313
Bilge Keels (2)	2692.4	2.313	2692.4	2.313	2692.4	2.313	2692.4	2.313
Pods (2)	3969.9	3.410	3969.9	3.410	3969.9	3.410		

Table A3. HSS HCRSP Resistance Prediction, Exp71, Fully Appended, HVY Displacement

HSS Exp71 HCRSP+Flap+BK HVY (PE from CR input)

	SHIP		MODEL	
LAMBDA			34.121	
LWL	947.9	ft	27.781	ft
S	115253	ft^2	98.994	ft^2
WT	40140	LT	2200.3	lbs
RHO	1.9905	$(lbf*sec^2)/ft$	1.9362	$(lbf*sec^2)/ft^4$
NU	1.28E-05	ft^2/sec	1.056E-05	ft^2/sec
Ca			0.0000	

Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15	8022	5982	4799	3579	0.145	0.487	0.952
16	9652	7197	5780	4310	0.155	0.520	0.943
17	11480	8561	6883	5133	0.164	0.552	0.933
18	13488	10058	8115	6052	0.174	0.585	0.919
19	15676	11690	9484	7072	0.184	0.617	0.900
20	18063	13469	10995	8199	0.193	0.650	0.881
21	20678	15419	12655	9437	0.203	0.682	0.864
22	23555	17565	14472	10791	0.213	0.715	0.851
23	26723	19928	16451	12267	0.222	0.747	0.842
24	30195	22516	18599	13869	0.232	0.780	0.837
25	33962	25325	20922	15602	0.242	0.812	0.832
26	37999	28336	23428	17470	0.251	0.844	0.827
27	42266	31518	26123	19480	0.261	0.877	0.818
28	46727	34844	29012	21634	0.271	0.909	0.805
29	51364	38302	32103	23939	0.280	0.942	0.788
30	56208	41915	35402	26399	0.290	0.974	0.769
31	61356	45753	38915	29019	0.300	1.007	0.751
32	66993	49957	42648	31803	0.309	1.039	0.741
33	73403	54737	46609	34756	0.319	1.072	0.744
34	80966	60376	50803	37884	0.329	1.104	0.765
35	90132	67212	55236	41189	0.338	1.137	0.812
36	101384	75602	59915	44679	0.348	1.169	0.886
37	115167	85880	64846	48356	0.358	1.202	0.991
38	131815	98295	70035	52225	0.367	1.234	1.123
39	151468	112949	75489	56292	0.377	1.267	1.277
40	174007	129757	81214	60561	0.387	1.299	1.446
41	199051	148432	87215	65036	0.396	1.332	1.618
42	227222	169440	93500	69723	0.406	1.364	1.800
43	256333	191147	100073	74625	0.416	1.397	1.960
44	286745	213825	106942	79747	0.425	1.429	2.105
45	317735	236935	114113	85094	0.435	1.462	2.228

Table A4. HSS HCRSP Resistance Prediction, Exp75, Fully Appended, DES Displacement

HSS Exp75 HCRSP+Flap+BK DES (PE from CR input)

	SHIP		MODEL	
LAMBDA			34.121	
LWL	978.2	ft	28.669	ft
S wPods	111619	ft^2	95.873	ft^2
WT	36491	LT	2000.3	lbs
RHO	1.9905	$(lbf*sec^2)/ft$	1.9362	$(lbf*sec^2)/ft^4$
NU	1.28E-05	ft^2/sec	1.055E-05	ft^2/sec
Ca			0.0000	

Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15	7390	5511	4630	3453	0.143	0.480	0.842
16	8807	6567	5577	4158	0.152	0.512	0.812
17	10401	7756	6641	4952	0.162	0.544	0.788
18	12186	9087	7830	5839	0.171	0.576	0.769
19	14116	10526	9151	6824	0.181	0.607	0.745
20	16264	12128	10609	7911	0.190	0.639	0.728
21	18625	13889	12211	9106	0.200	0.671	0.713
22	21232	15833	13964	10413	0.209	0.703	0.703
23	24110	17979	15874	11837	0.219	0.735	0.697
24	27276	20340	17947	13383	0.228	0.767	0.695
25	30726	22912	20189	15055	0.238	0.799	0.694
26	34441	25683	22607	16858	0.247	0.831	0.693
27	38391	28628	25207	18797	0.257	0.863	0.690
28	42545	31726	27996	20876	0.266	0.895	0.682
29	46891	34967	30979	23101	0.276	0.927	0.672
30	51459	38373	34162	25475	0.285	0.959	0.660
31	56335	42009	37552	28003	0.295	0.991	0.649
32	61687	46000	41156	30690	0.304	1.023	0.645
33	67770	50536	44978	33540	0.314	1.055	0.653
34	74926	55872	49025	36558	0.323	1.087	0.679
35	83558	62309	53303	39748	0.333	1.119	0.727
36	94100	70170	57819	43116	0.342	1.151	0.801
37	106949	79752	62578	46664	0.352	1.183	0.902
38	122400	91274	67586	50399	0.362	1.215	1.029
39	140564	104819	72850	54324	0.371	1.247	1.175
40	161309	120288	78375	58444	0.381	1.279	1.334
41	184243	137390	84167	62763	0.390	1.311	1.495
42	209306	156079	90232	67286	0.400	1.343	1.655
43	235323	175481	96576	72017	0.409	1.375	1.797
44	262614	195831	103206	76961	0.419	1.407	1.927
45	289714	216040	110126	82121	0.428	1.439	2.029

Table A5. HSS HCRSP Resistance Prediction, Exp92, Fully Appended, LITE Displacement

HSS Exp92 HCRSP+Flap+BK LITE (PE from CR input)

	SHIP		MODEL	
LAMBDA			34.121	
LWL	976.4	ft	28.616	ft
S wPods	104464	ft^2	89.727	ft^2
WT	32841	LT	1800.2	lbs
RHO	1.9905	$(lbf*sec^2)/ft$	1.9362	$(lbf*sec^2)/ft^4$
NU	1.28E-05	ft^2/sec	1.055E-05	ft^2/sec
Ca			0.0000	

Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15	7381	5504	4335	3232	0.143	0.480	0.993
16	8704	6490	5220	3893	0.152	0.512	0.936
17	10144	7565	6217	4636	0.162	0.544	0.880
18	11720	8740	7330	5466	0.171	0.576	0.828
19	13461	10038	8566	6388	0.181	0.608	0.785
20	15401	11484	9931	7406	0.190	0.640	0.752
21	17577	13107	11431	8524	0.200	0.672	0.730
22	20021	14929	13072	9748	0.209	0.704	0.718
23	22755	16969	14859	11081	0.219	0.736	0.714
24	25789	19231	16800	12528	0.229	0.768	0.715
25	29117	21712	18899	14093	0.238	0.800	0.720
26	32720	24400	21163	15781	0.248	0.832	0.724
27	36577	27275	23597	17596	0.257	0.864	0.726
28	40667	30326	26207	19542	0.267	0.896	0.725
29	44991	33550	28999	21625	0.276	0.928	0.721
30	49580	36972	31979	23847	0.286	0.960	0.717
31	54513	40651	35153	26213	0.295	0.992	0.715
32	59930	44690	38526	28729	0.305	1.024	0.719
33	66033	49241	42103	31397	0.314	1.056	0.733
34	73094	54506	45892	34222	0.324	1.088	0.761
35	81432	60724	49897	37208	0.333	1.120	0.809
36	91399	68157	54124	40360	0.343	1.152	0.879
37	103335	77057	58579	43682	0.352	1.184	0.972
38	117520	87635	63267	47178	0.362	1.216	1.088
39	134122	100015	68194	50852	0.371	1.248	1.223
40	153138	114195	73366	54709	0.381	1.280	1.371
41	174352	130014	78788	58752	0.390	1.312	1.526
42	197330	147149	84465	62986	0.400	1.344	1.676
43	221469	165149	90404	67414	0.409	1.376	1.814
44	246145	183551	96610	72042	0.419	1.408	1.931
45	271008	202091	103088	76873	0.429	1.440	2.028

Table A6. HSS HCRSP Resistance Prediction, Exp94, Flap Removed, DES Displacement

HSS Exp94 HCRSP+BK DES NoFlap (PE from CR input)

	SHIP		MODEL	
LAMBDA			34.121	
LWL	978.2	ft	28.669	ft
S wPods	111619	ft^2	95.873	ft^2
WT	36491	LT	2000.3	lbs
RHO	1.9905	$(lbf*sec^2)/ft$	1.9362	$(lbf*sec^2)/ft^4$
NU	1.28E-05	ft^2/sec	1.055E-05	ft^2/sec
Ca			0.0000	

Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15	7272	5423	4630	3453	0.143	0.480	0.806
16	8699	6487	5577	4158	0.152	0.512	0.785
17	10281	7667	6641	4952	0.162	0.544	0.763
18	12050	8985	7830	5839	0.171	0.576	0.745
19	14033	10465	9151	6824	0.181	0.607	0.733
20	16249	12117	10609	7911	0.190	0.639	0.726
21	18686	13935	12211	9106	0.200	0.671	0.720
22	21388	15949	13964	10413	0.209	0.703	0.718
23	24405	18198	15874	11837	0.219	0.735	0.722
24	27706	20661	17947	13383	0.228	0.767	0.727
25	31281	23326	20189	15055	0.238	0.799	0.731
26	35101	26175	22607	16858	0.247	0.831	0.732
27	39161	29202	25207	18797	0.257	0.863	0.730
28	43579	32497	27996	20876	0.266	0.895	0.731
29	48174	35923	30979	23101	0.276	0.927	0.726
30	53093	39592	34162	25475	0.285	0.959	0.722
31	58382	43536	37552	28003	0.295	0.991	0.720
32	64385	48012	41156	30690	0.304	1.023	0.730
33	71082	53006	44978	33540	0.314	1.055	0.748
34	78797	58759	49025	36558	0.323	1.087	0.780
35	87903	65550	53303	39748	0.333	1.119	0.831
36	98551	73490	57819	43116	0.342	1.151	0.899
37	111620	83235	62578	46664	0.352	1.183	0.997
38	127641	95182	67586	50399	0.362	1.215	1.127
39	146873	109523	72850	54324	0.371	1.247	1.285
40	168680	125785	78375	58444	0.381	1.279	1.453
41	193062	143966	84167	62763	0.390	1.311	1.627
42	219163	163430	90232	67286	0.400	1.343	1.792
43	246133	183541	96576	72017	0.409	1.375	1.937
44	273202	203727	103206	76961	0.419	1.407	2.055
45	299943	223668	110126	82121	0.428	1.439	2.145

Table A7. HSS 2-Screw (Pods Removed) Resistance Prediction, Exp96, DES Displacement

HSS Exp96 TwinScrew+BK DES NoPods NoFlap (PE from CR input)

	SHIP		MODEL	
LAMBDA			34.121	
LWL	978.2	ft	28.669	ft
S wPods	107649.1	ft^2	92.463	ft^2
WT	36491	LT	2000.3	lbs
RHO	1.9905	$(lbf*sec^2)/ft$	1.9362	$(lbf*sec^2)/ft^4$
NU	1.28E-05	ft^2/sec	1.055E-05	ft^2/sec
Ca			0.0000	

Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15	6542	4879	4466	3330	0.143	0.480	0.657
16	7753	5781	5378	4011	0.152	0.512	0.619
17	9097	6783	6405	4776	0.162	0.544	0.585
18	10605	7908	7552	5631	0.171	0.576	0.559
19	12301	9173	8825	6581	0.181	0.607	0.541
20	14203	10591	10232	7630	0.190	0.639	0.530
21	16339	12184	11777	8782	0.200	0.671	0.526
22	18723	13962	13467	10043	0.209	0.703	0.527
23	21337	15911	15309	11416	0.219	0.735	0.529
24	24196	18043	17308	12907	0.228	0.767	0.532
25	27271	20336	19471	14519	0.238	0.799	0.533
26	30577	22801	21803	16259	0.247	0.831	0.533
27	34100	25428	24311	18129	0.257	0.863	0.531
28	37856	28229	27000	20134	0.266	0.895	0.528
29	41892	31239	29877	22279	0.276	0.927	0.526
30	46274	34506	32947	24569	0.285	0.959	0.527
31	51088	38097	36217	27007	0.295	0.991	0.533
32	56418	42071	39692	29598	0.304	1.023	0.545
33	62395	46528	43378	32347	0.314	1.055	0.565
34	69663	51947	47281	35258	0.323	1.087	0.608
35	78192	58307	51408	38335	0.333	1.119	0.667
36	88273	65825	55763	41582	0.342	1.151	0.744
37	100202	74721	60352	45005	0.352	1.183	0.840
38	114262	85205	65182	48607	0.362	1.215	0.955
39	130760	97508	70259	52392	0.371	1.247	1.089
40	149794	111701	75587	56365	0.381	1.279	1.238
41	171349	127775	81173	60531	0.390	1.311	1.397
42	195269	145612	87023	64893	0.400	1.343	1.560
43	220997	164797	93141	69456	0.409	1.375	1.717
44	247529	184583	99535	74223	0.419	1.407	1.855
45	273657	204066	106209	79200	0.428	1.439	1.962

Table A8. HSS Hullform (Shafts Removed) Resistance Prediction, Exp99, DES Displacement

HSS Exp99 Hull+BK only DES (PE from CR input)

	SHIP		MODEL	
LAMBDA			34.121	
LWL	978.2	ft	28.669	ft
S wPods	107649.1	ft^2	92.463	ft^2
WT	36491	LT	2000.3	lbs
RHO	1.9905	$(lbf*sec^2)/ft$	1.9362	$(lbf*sec^2)/ft^4$
NU	1.28E-05	ft^2/sec	1.055E-05	ft^2/sec
Ca			0.0000	

Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15	5680	4235	4466	3330	0.143	0.480	0.384
16	6740	5026	5378	4011	0.152	0.512	0.355
17	7933	5915	6405	4776	0.162	0.544	0.332
18	9250	6898	7552	5631	0.171	0.576	0.311
19	10707	7985	8825	6581	0.181	0.607	0.293
20	12329	9194	10232	7630	0.190	0.639	0.280
21	14145	10548	11777	8782	0.200	0.671	0.273
22	16210	12088	13467	10043	0.209	0.703	0.275
23	18534	13821	15309	11416	0.219	0.735	0.283
24	21154	15774	17308	12907	0.228	0.767	0.297
25	24051	17935	19471	14519	0.238	0.799	0.313
26	27202	20285	21803	16259	0.247	0.831	0.328
27	30597	22816	24311	18129	0.257	0.863	0.341
28	34175	25485	27000	20134	0.266	0.895	0.349
29	37917	28275	29877	22279	0.276	0.927	0.352
30	41848	31206	32947	24569	0.285	0.959	0.352
31	46010	34310	36217	27007	0.295	0.991	0.351
32	50587	37723	39692	29598	0.304	1.023	0.355
33	55798	41608	43378	32347	0.314	1.055	0.369
34	61969	46210	47281	35258	0.323	1.087	0.399
35	69438	51780	51408	38335	0.333	1.119	0.449
36	78704	58689	55763	41582	0.342	1.151	0.525
37	90098	67186	60352	45005	0.352	1.183	0.627
38	103932	77502	65182	48607	0.362	1.215	0.754
39	120427	89802	70259	52392	0.371	1.247	0.903
40	139424	103969	75587	56365	0.381	1.279	1.065
41	160634	119785	81173	60531	0.390	1.311	1.231
42	183473	136816	87023	64893	0.400	1.343	1.390
43	207370	154636	93141	69456	0.409	1.375	1.534
44	232052	173041	99535	74223	0.419	1.407	1.661
45	258039	192420	106209	79200	0.428	1.439	1.779

Note: This condition does not represent bare hull, as bilge keels were attached to the model.

Table A9. HSS HCRSP Resistance Comparisons, Three Tested Displacements

HSS HCRSP Resistance Comparisons at Three Tested Displacements

VS (knots)	Heavy (HVY) PE (hp)	Design (DES) PE (hp)	Light (LITE) PE (hp)	HVY / DES PE Ratio	LITE / DES PE Ratio
15	8022	7390	7381	1.085	0.999
16	9652	8807	8704	1.096	0.988
17	11480	10401	10144	1.104	0.975
18	13488	12186	11720	1.107	0.962
19	15676	14116	13461	1.111	0.954
20	18063	16264	15401	1.111	0.947
21	20678	18625	17577	1.110	0.944
22	23555	21232	20021	1.109	0.943
23	26723	24110	22755	1.108	0.944
24	30195	27276	25789	1.107	0.945
25	33962	30726	29117	1.105	0.948
26	37999	34441	32720	1.103	0.950
27	42266	38391	36577	1.101	0.953
28	46727	42545	40667	1.098	0.956
29	51364	46891	44991	1.095	0.959
30	56208	51459	49580	1.092	0.963
31	61356	56335	54513	1.089	0.968
32	66993	61687	59930	1.086	0.972
33	73403	67770	66033	1.083	0.974
34	80966	74926	73094	1.081	0.976
35	90132	83558	81432	1.079	0.975
36	101384	94100	91399	1.077	0.971
37	115167	106949	103335	1.077	0.966
38	131815	122400	117520	1.077	0.960
39	151468	140564	134122	1.078	0.954
40	174007	161309	153138	1.079	0.949
41	199051	184243	174352	1.080	0.946
42	227222	209306	197330	1.086	0.943
43	256333	235323	221469	1.089	0.941
44	286745	262614	246145	1.092	0.937
45	317735	289714	271008	1.097	0.935
				1.093	0.958

Table A10. HSS Hullform Resistance Comparisons of Tested Appendage Configurations, DES Displacement

HSS Resistance Comparisons of Tested Appendage Configurations at DES Displacement

VS (knots)	Fully Appended PE (hp)	Flap Removed PE (hp)	Two Pods Removed PE (hp)	Two S&S Removed PE (hp)	Stern Flap Δ PE (hP)	Twin Pods Δ PE (hP)	Twin Shafts Δ PE (hP)	Stern Flap / No Flap PE Ratio	Twin Pods / No Pods PE Ratio	Twin Shafts / No Shafts PE Ratio
15	7390	7272	6542	5680	118	730	863	1.016	1.112	1.152
16	8807	8699	7753	6740	107	946	1013	1.012	1.122	1.150
17	10401	10281	9097	7933	119	1185	1164	1.012	1.130	1.147
18	12186	12050	10605	9250	136	1445	1355	1.011	1.136	1.146
19	14116	14033	12301	10707	83	1733	1593	1.006	1.141	1.149
20	16264	16249	14203	12329	15	2046	1873	1.001	1.144	1.152
21	18625	18686	16339	14145	-61	2347	2194	0.997	1.144	1.155
22	21232	21388	18723	16210	-156	2665	2513	0.993	1.142	1.155
23	24110	24405	21337	18534	-294	3067	2803	0.988	1.144	1.151
24	27276	27706	24196	21154	-430	3510	3043	0.984	1.145	1.144
25	30726	31281	27271	24051	-555	4010	3219	0.982	1.147	1.134
26	34441	35101	30577	27202	-660	4524	3375	0.981	1.148	1.124
27	38391	39161	34100	30597	-770	5061	3503	0.980	1.148	1.114
28	42545	43579	37856	34175	-1035	5724	3680	0.976	1.151	1.108
29	46891	48174	41892	37917	-1282	6282	3975	0.973	1.150	1.105
30	51459	53093	46274	41848	-1635	6819	4425	0.969	1.147	1.106
31	56335	58382	51088	46010	-2048	7294	5078	0.965	1.143	1.110
32	61687	64385	56418	50587	-2698	7968	5831	0.958	1.141	1.115
33	67770	71082	62395	55798	-3312	8688	6597	0.953	1.139	1.118
34	74926	78797	69663	61969	-3871	9134	7694	0.951	1.131	1.124
35	83558	87903	78192	69438	-4345	9712	8754	0.951	1.124	1.126
36	94100	98551	88273	78704	-4451	10278	9570	0.955	1.116	1.122
37	106949	111620	100202	90098	-4671	11418	10105	0.958	1.114	1.112
38	122400	127641	114262	103932	-5240	13379	10330	0.959	1.117	1.099
39	140564	146873	130760	120427	-6309	16113	10334	0.957	1.123	1.086
40	161309	168680	149794	139424	-7371	18887	10370	0.956	1.126	1.074
41	184243	193062	171349	160634	-8819	21713	10715	0.954	1.127	1.067
42	209306	219163	195269	183473	-9857	23893	11796	0.955	1.122	1.064
43	235323	246133	220997	207370	-10809	25136	13627	0.956	1.114	1.066
44	262614	273202	247529	232052	-10589	25673	15478	0.961	1.104	1.067
45	289714	299943	273657	258039	-10229	26286	15618	0.966	1.096	1.061
								0.975	1.132	1.116

Table A11. HSS HCRSP Powering Prediction, Exp73, Fully Appended, HVY Displacement, F:A RPM = 1:1

HSS-HCRSP Exp73 FA+Flap+BK HVY 1:1

LENGTH (LWL)	947.9 FT (288.9 M)
DISPLACEMENT	40142.5 TONS (40784.8 TONNES)
WETTED SURFACE	115253.0 SQ FT (10707.4 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	8022.	5982.	11487.	8566.	0.698	0.771	0.824	0.824	2.370	1.418	0.952
16.0	8.23	9652.	7197.	13766.	10265.	0.701	0.770	0.833	0.812	2.350	1.407	0.943
17.0	8.75	11480.	8561.	16400.	12230.	0.700	0.770	0.831	0.810	2.330	1.397	0.933
18.0	9.26	13488.	10058.	19361.	14438.	0.697	0.771	0.824	0.813	2.306	1.388	0.919
19.0	9.77	15676.	11690.	22622.	16869.	0.693	0.773	0.816	0.818	2.279	1.379	0.900
20.0	10.29	18063.	13470.	26151.	19501.	0.691	0.774	0.808	0.826	2.252	1.371	0.881
21.0	10.80	20678.	15420.	29946.	22331.	0.691	0.775	0.802	0.833	2.227	1.363	0.864
22.0	11.32	23555.	17565.	33969.	25330.	0.693	0.776	0.800	0.838	2.206	1.355	0.851
23.0	11.83	26723.	19927.	38201.	28486.	0.700	0.777	0.801	0.844	2.190	1.348	0.842
24.0	12.35	30195.	22516.	42725.	31860.	0.707	0.777	0.804	0.848	2.178	1.342	0.837
25.0	12.86	33962.	25325.	47465.	35394.	0.716	0.777	0.808	0.851	2.168	1.335	0.832
26.0	13.38	37999.	28336.	52478.	39133.	0.724	0.777	0.814	0.853	2.156	1.329	0.827
27.0	13.89	42266.	31518.	57919.	43190.	0.730	0.778	0.818	0.854	2.141	1.324	0.818
28.0	14.40	46727.	34844.	63749.	47538.	0.733	0.778	0.820	0.854	2.123	1.318	0.805
29.0	14.92	51364.	38302.	70098.	52272.	0.733	0.779	0.820	0.853	2.100	1.313	0.788
30.0	15.43	56208.	41914.	77184.	57556.	0.728	0.779	0.817	0.852	2.076	1.308	0.768
31.0	15.95	61356.	45753.	85001.	63385.	0.722	0.780	0.813	0.850	2.054	1.303	0.751
32.0	16.46	66993.	49957.	93923.	70039.	0.713	0.780	0.807	0.849	2.039	1.298	0.741
33.0	16.98	73403.	54737.	104161.	77673.	0.705	0.781	0.800	0.847	2.037	1.293	0.744
34.0	17.49	80966.	60376.	115952.	86465.	0.698	0.781	0.795	0.846	2.054	1.289	0.765
35.0	18.01	90132.	67211.	129526.	96587.	0.696	0.780	0.792	0.845	2.096	1.285	0.812
36.0	18.52	101384.	75602.	145584.	108562.	0.696	0.778	0.791	0.845	2.167	1.281	0.886
37.0	19.03	115167.	85880.	164301.	122519.	0.701	0.776	0.792	0.846	2.267	1.277	0.991
38.0	19.55	131815.	98294.	186553.	139113.	0.707	0.773	0.792	0.848	2.396	1.273	1.123
39.0	20.06	151468.	112950.	212754.	158651.	0.712	0.769	0.792	0.850	2.546	1.269	1.277
40.0	20.58	174007.	129757.	243775.	181783.	0.714	0.764	0.789	0.853	2.711	1.266	1.446
41.0	21.09	199051.	148432.	280244.	208978.	0.710	0.760	0.782	0.857	2.880	1.262	1.618
42.0	21.61	227222.	169439.	323355.	241126.	0.703	0.756	0.773	0.861	3.059	1.259	1.800

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A11. HSS HCRSP Powering Prediction, Exp73, Fully Appended, HVY Displacement, F:A RPM = 1:1 (continued)

HSS-HCRSP Exp73 FA+Flap+BK HVY 1:1

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3770.	2811.	59.7	27.07	460.9	63.7	0.740	0.707	0.955	0.970	0.945	1.595	43.0
16.00	4510.	3363.	68.6	31.13	517.9	71.6	0.739	0.719	0.974	0.963	0.948	1.586	45.7
17.00	5345.	3985.	77.1	34.95	578.3	80.0	0.739	0.724	0.980	0.963	0.952	1.588	48.5
18.00	6268.	4674.	84.9	38.51	641.3	88.7	0.740	0.724	0.978	0.967	0.955	1.598	51.3
19.00	7271.	5422.	92.5	41.94	705.7	97.6	0.741	0.722	0.973	0.973	0.959	1.610	54.1
20.00	8347.	6224.	99.8	45.28	771.0	106.6	0.743	0.719	0.968	0.979	0.963	1.623	56.9
21.00	9503.	7086.	107.5	48.78	837.5	115.8	0.744	0.718	0.965	0.984	0.967	1.634	59.6
22.00	10726.	7999.	115.8	52.54	904.5	125.1	0.744	0.719	0.966	0.987	0.970	1.642	62.3
23.00	12016.	8960.	124.5	56.49	971.5	134.4	0.745	0.723	0.971	0.988	0.974	1.648	65.0
24.00	13408.	9998.	134.2	60.85	1042.0	144.1	0.745	0.727	0.976	0.987	0.975	1.650	67.6
25.00	14870.	11088.	144.3	65.45	1112.7	153.9	0.745	0.733	0.984	0.984	0.977	1.652	70.2
26.00	16436.	12256.	155.0	70.32	1186.1	164.0	0.745	0.739	0.992	0.982	0.978	1.652	72.8
27.00	18155.	13539.	166.3	75.42	1265.4	175.0	0.745	0.743	0.997	0.979	0.977	1.652	75.4
28.00	20003.	14916.	177.7	80.61	1348.4	186.5	0.745	0.745	1.000	0.976	0.976	1.652	77.9
29.00	22026.	16425.	189.6	86.01	1436.9	198.7	0.745	0.746	1.002	0.974	0.974	1.653	80.5
30.00	24311.	18129.	201.6	91.46	1535.9	212.4	0.745	0.743	0.997	0.973	0.972	1.654	83.1
31.00	26816.	19997.	214.4	97.26	1641.4	227.0	0.745	0.740	0.993	0.972	0.969	1.655	85.8
32.00	29695.	22144.	228.3	103.57	1760.9	243.5	0.745	0.734	0.986	0.973	0.966	1.655	88.6
33.00	33005.	24612.	243.9	110.63	1895.6	262.2	0.745	0.728	0.977	0.973	0.963	1.654	91.4
34.00	36803.	27444.	262.5	119.08	2046.7	283.1	0.745	0.724	0.972	0.972	0.960	1.649	94.4
35.00	41119.	30662.	285.0	129.30	2212.2	305.9	0.744	0.723	0.972	0.971	0.958	1.641	97.6
36.00	46252.	34490.	312.6	141.78	2406.4	332.8	0.743	0.723	0.973	0.968	0.955	1.627	100.9
37.00	52159.	38895.	345.5	156.71	2619.9	362.3	0.741	0.726	0.979	0.965	0.955	1.609	104.6
38.00	59163.	44118.	384.5	174.40	2867.5	396.6	0.739	0.728	0.986	0.961	0.954	1.588	108.4
39.00	67379.	50245.	429.3	194.73	3147.3	435.3	0.736	0.730	0.993	0.957	0.953	1.564	112.4
40.00	76994.	57415.	478.3	216.94	3461.4	478.7	0.732	0.730	0.996	0.957	0.955	1.544	116.8
41.00	88232.	65794.	530.2	240.49	3814.7	527.6	0.729	0.726	0.995	0.960	0.957	1.527	121.5
42.00	******	75643.	586.1	265.85	4211.3	582.4	0.727	0.720	0.991	0.967	0.961	1.513	126.5

Table A11. HSS HCRSP Powering Prediction, Exp73, Fully Appended, HVY Displacement, F:A RPM = 1:1 (continued)

HSS-HCRSP Exp73 FA+Flap+BK HVY 1:1

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1974.	1472.	46.1	20.89	241.4	33.4	0.802	0.942	1.175	0.877	0.953	1.824	42.9
16.00	2373.	1769.	52.4	23.77	272.5	37.7	0.801	0.947	1.183	0.874	0.953	1.821	45.7
17.00	2856.	2130.	58.8	26.69	309.2	42.8	0.801	0.939	1.172	0.873	0.949	1.823	48.5
18.00	3413.	2545.	65.3	29.62	349.5	48.3	0.802	0.925	1.152	0.875	0.942	1.829	51.3
19.00	4040.	3013.	71.8	32.57	392.3	54.3	0.804	0.910	1.132	0.879	0.937	1.838	54.1
20.00	4729.	3526.	78.4	35.54	436.8	60.4	0.806	0.897	1.113	0.882	0.933	1.848	56.9
21.00	5470.	4079.	85.2	38.63	482.2	66.7	0.807	0.887	1.099	0.884	0.929	1.856	59.6
22.00	6258.	4667.	92.3	41.87	527.8	73.0	0.808	0.881	1.090	0.885	0.926	1.862	62.3
23.00	7085.	5283.	99.7	45.24	572.9	79.2	0.809	0.880	1.087	0.885	0.924	1.867	65.0
24.00	7954.	5932.	107.7	48.84	618.2	85.5	0.809	0.881	1.089	0.884	0.923	1.870	67.6
25.00	8863.	6609.	115.8	52.51	663.4	91.7	0.810	0.884	1.091	0.882	0.922	1.871	70.2
26.00	9804.	7311.	124.0	56.26	707.9	97.9	0.810	0.888	1.097	0.880	0.922	1.874	72.7
27.00	10804.	8057.	132.4	60.07	753.4	104.2	0.811	0.893	1.101	0.879	0.923	1.877	75.3
28.00	11872.	8853.	140.6	63.77	800.5	110.7	0.811	0.895	1.103	0.879	0.923	1.882	77.9
29.00	13023.	9711.	148.6	67.41	849.9	117.5	0.813	0.894	1.101	0.881	0.923	1.890	80.5
30.00	14280.	10649.	156.7	71.08	902.5	124.8	0.814	0.892	1.096	0.883	0.923	1.898	83.1
31.00	15684.	11696.	164.9	74.78	960.2	132.8	0.815	0.886	1.088	0.886	0.923	1.908	85.8
32.00	17266.	12875.	173.7	78.78	1024.0	141.6	0.816	0.879	1.078	0.890	0.922	1.916	88.6
33.00	19076.	14225.	184.0	83.45	1096.0	151.6	0.816	0.872	1.068	0.893	0.921	1.920	91.4
34.00	21173.	15789.	196.2	88.98	1178.0	162.9	0.816	0.865	1.060	0.895	0.920	1.920	94.4
35.00	23644.	17632.	211.5	95.93	1272.5	176.0	0.816	0.861	1.055	0.896	0.920	1.914	97.6
36.00	26540.	19791.	230.6	104.59	1380.9	191.0	0.814	0.859	1.055	0.895	0.919	1.900	100.9
37.00	29991.	22365.	254.1	115.25	1507.6	208.5	0.811	0.857	1.057	0.891	0.917	1.879	104.5
38.00	34114.	25439.	282.3	128.06	1653.8	228.7	0.807	0.856	1.061	0.887	0.916	1.854	108.3
39.00	38998.	29081.	315.5	143.09	1821.8	252.0	0.802	0.855	1.066	0.883	0.916	1.824	112.4
40.00	44893.	33477.	352.6	159.95	2019.1	279.2	0.796	0.848	1.066	0.880	0.914	1.795	116.8
41.00	51890.	38695.	393.2	178.34	2243.4	310.3	0.790	0.839	1.062	0.880	0.914	1.769	121.5
42.00	60239.	44920.	437.7	198.53	2501.8	346.0	0.785	0.826	1.053	0.882	0.912	1.745	126.5

Table A12. HSS HCRSP Powering Prediction, Exp76, Fully Appended, DES Displacement, F:A RPM = 1:1

HSS-HCRSP Exp76 FA+Flap+BK DES 1:1

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	7390.	5511.	10593.	7899.	0.698	0.783	0.836	0.842	2.255	1.413	0.842
16.0	8.23	8807.	6567.	12195.	9094.	0.722	0.783	0.839	0.866	2.214	1.402	0.812
17.0	8.75	10401.	7756.	14211.	10597.	0.732	0.783	0.830	0.884	2.180	1.392	0.788
18.0	9.26	12186.	9087.	16606.	12383.	0.734	0.783	0.819	0.897	2.152	1.383	0.769
19.0	9.77	14116.	10526.	19322.	14409.	0.731	0.783	0.806	0.907	2.119	1.374	0.745
20.0	10.29	16264.	12128.	22356.	16671.	0.728	0.783	0.796	0.914	2.093	1.366	0.728
21.0	10.80	18625.	13889.	25718.	19178.	0.724	0.783	0.788	0.919	2.071	1.358	0.713
22.0	11.32	21232.	15833.	29345.	21882.	0.724	0.783	0.785	0.921	2.053	1.350	0.703
23.0	11.83	24110.	17979.	33193.	24752.	0.726	0.783	0.784	0.921	2.041	1.343	0.697
24.0	12.35	27276.	20340.	37271.	27793.	0.732	0.783	0.786	0.921	2.032	1.337	0.695
25.0	12.86	30726.	22912.	41614.	31032.	0.738	0.783	0.791	0.919	2.025	1.331	0.694
26.0	13.38	34441.	25683.	46289.	34518.	0.744	0.783	0.795	0.916	2.018	1.325	0.693
27.0	13.89	38391.	28628.	51300.	38254.	0.748	0.783	0.799	0.913	2.008	1.319	0.690
28.0	14.40	42545.	31726.	56687.	42272.	0.751	0.783	0.802	0.909	1.996	1.313	0.682
29.0	14.92	46891.	34967.	62545.	46640.	0.750	0.783	0.803	0.905	1.980	1.308	0.672
30.0	15.43	51459.	38373.	69108.	51534.	0.745	0.783	0.800	0.901	1.963	1.303	0.660
31.0	15.95	56335.	42009.	76400.	56971.	0.737	0.783	0.797	0.895	1.947	1.298	0.649
32.0	16.46	61687.	46000.	84612.	63095.	0.729	0.783	0.792	0.891	1.939	1.293	0.645
33.0	16.98	67770.	50536.	94097.	70168.	0.720	0.783	0.787	0.887	1.942	1.289	0.653
34.0	17.49	74926.	55872.	104971.	78277.	0.714	0.783	0.783	0.883	1.963	1.284	0.679
35.0	18.01	83558.	62309.	117769.	87820.	0.710	0.783	0.780	0.881	2.007	1.280	0.727
36.0	18.52	94100.	70170.	132726.	98974.	0.709	0.783	0.780	0.879	2.077	1.276	0.801
37.0	19.03	106949.	79752.	150336.	112105.	0.711	0.783	0.781	0.878	2.174	1.272	0.902
38.0	19.55	122400.	91274.	171151.	127628.	0.715	0.782	0.784	0.877	2.297	1.268	1.029
39.0	20.06	140564.	104819.	196111.	146240.	0.717	0.781	0.786	0.877	2.440	1.265	1.175
40.0	20.58	161309.	120288.	225735.	168331.	0.715	0.780	0.785	0.877	2.595	1.261	1.334
41.0	21.09	184243.	137390.	260972.	194607.	0.706	0.779	0.780	0.878	2.753	1.258	1.495
42.0	21.61	209306.	156079.	303403.	226247.	0.690	0.778	0.773	0.879	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A12. HSS HCRSP Powering Prediction, Exp76, Fully Appended, DES Displacement, F:A RPM = 1:1 - continued

HSS-HCRSP Exp76&78 FA+Flap+BK DES 1:1

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3473.	2590.	51.6	23.40	427.4	59.1	0.745	0.689	0.925	1.008	0.972	1.669	42.7
16.00	3989.	2974.	56.8	25.75	464.4	64.2	0.746	0.701	0.940	1.004	0.976	1.677	45.1
17.00	4643.	3463.	62.4	28.30	512.8	70.9	0.746	0.700	0.939	0.999	0.972	1.682	47.6
18.00	5421.	4042.	68.5	31.08	568.4	78.6	0.746	0.696	0.933	0.997	0.967	1.687	50.1
19.00	6291.	4691.	74.7	33.89	627.1	86.7	0.745	0.690	0.926	0.997	0.965	1.694	52.7
20.00	7261.	5414.	81.5	36.96	689.7	95.4	0.745	0.687	0.921	0.997	0.963	1.698	55.3
21.00	8330.	6211.	88.5	40.16	754.9	104.4	0.745	0.684	0.918	0.998	0.963	1.703	58.0
22.00	9479.	7068.	96.2	43.65	821.4	113.6	0.745	0.684	0.918	0.998	0.963	1.706	60.6
23.00	10687.	7969.	104.5	47.41	888.4	122.9	0.745	0.687	0.922	0.995	0.963	1.706	63.2
24.00	11963.	8921.	113.2	51.34	955.3	132.1	0.745	0.692	0.929	0.993	0.964	1.707	65.8
25.00	13313.	9927.	122.6	55.59	1023.5	141.6	0.745	0.699	0.938	0.989	0.964	1.705	68.3
26.00	14769.	11013.	132.2	59.99	1094.3	151.3	0.745	0.705	0.946	0.986	0.964	1.704	70.9
27.00	16323.	12172.	142.1	64.47	1167.3	161.4	0.745	0.710	0.953	0.984	0.965	1.704	73.4
28.00	17997.	13420.	152.3	69.06	1244.0	172.0	0.745	0.713	0.957	0.981	0.964	1.703	76.0
29.00	19802.	14766.	162.6	73.77	1323.1	183.0	0.745	0.717	0.962	0.981	0.966	1.704	78.6
30.00	21842.	16287.	172.9	78.45	1412.3	195.3	0.745	0.715	0.960	0.980	0.965	1.706	81.2
31.00	24116.	17983.	184.1	83.52	1510.0	208.8	0.745	0.712	0.956	0.980	0.963	1.707	83.9
32.00	26681.	19896.	196.1	88.93	1616.5	223.6	0.745	0.709	0.952	0.982	0.963	1.708	86.7
33.00	29672.	22126.	209.9	95.22	1740.2	240.7	0.745	0.704	0.946	0.983	0.962	1.707	89.6
34.00	33095.	24679.	226.4	102.69	1878.4	259.8	0.745	0.702	0.942	0.983	0.960	1.702	92.5
35.00	37170.	27718.	246.8	111.96	2041.2	282.3	0.745	0.700	0.939	0.982	0.956	1.693	95.6
36.00	41934.	31270.	271.6	123.20	2225.9	307.8	0.746	0.701	0.940	0.980	0.954	1.680	98.9
37.00	47575.	35477.	301.9	136.94	2437.0	337.0	0.745	0.705	0.945	0.978	0.953	1.662	102.5
38.00	54255.	40458.	338.6	153.59	2680.6	370.7	0.744	0.709	0.952	0.974	0.950	1.640	106.3
39.00	62307.	46462.	380.3	172.52	2963.8	409.9	0.742	0.710	0.956	0.972	0.949	1.617	110.4
40.00	71885.	53604.	427.8	194.04	3285.8	454.4	0.740	0.710	0.960	0.972	0.950	1.594	114.9
41.00	83292.	62111.	478.6	217.07	3653.3	505.2	0.737	0.706	0.958	0.977	0.952	1.576	119.7
42.00	97081.	72393.	532.8	241.68	4074.2	563.5	0.735	0.699	0.951	0.989	0.958	1.563	125.1

Table A12. HSS HCRSP Powering Prediction, Exp76, Fully Appended, DES Displacement, F:A RPM = 1:1 - continued

HSS-HCRSP Exp76&78 FA+Flap+BK DES 1:1

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1824.	1360.	43.7	19.83	224.5	31.1	0.820	0.982	1.197	0.890	0.971	1.864	42.7
16.00	2109.	1573.	46.9	21.25	245.7	34.0	0.820	0.976	1.190	0.895	0.969	1.891	45.1
17.00	2462.	1836.	50.4	22.88	272.1	37.6	0.821	0.960	1.170	0.898	0.964	1.913	47.5
18.00	2882.	2149.	54.5	24.72	302.3	41.8	0.821	0.942	1.147	0.902	0.958	1.931	50.1
19.00	3371.	2513.	58.8	26.65	336.2	46.5	0.821	0.921	1.121	0.906	0.953	1.948	52.7
20.00	3917.	2921.	63.5	28.81	372.4	51.5	0.822	0.904	1.101	0.909	0.947	1.959	55.2
21.00	4529.	3378.	68.7	31.18	410.7	56.8	0.822	0.892	1.085	0.912	0.945	1.969	57.9
22.00	5194.	3873.	74.5	33.80	450.1	62.2	0.822	0.885	1.077	0.914	0.943	1.976	60.6
23.00	5909.	4407.	80.9	36.72	491.4	68.0	0.822	0.881	1.071	0.911	0.938	1.975	63.2
24.00	6672.	4975.	87.8	39.85	533.2	73.7	0.822	0.880	1.070	0.908	0.935	1.974	65.7
25.00	7494.	5588.	95.4	43.25	576.3	79.7	0.822	0.883	1.074	0.904	0.932	1.971	68.3
26.00	8376.	6246.	103.4	46.89	621.0	85.9	0.822	0.886	1.077	0.899	0.929	1.966	70.8
27.00	9327.	6955.	111.6	50.62	667.5	92.3	0.822	0.888	1.080	0.896	0.926	1.962	73.4
28.00	10347.	7715.	120.1	54.46	715.3	98.9	0.822	0.890	1.083	0.893	0.925	1.960	76.0
29.00	11470.	8553.	128.6	58.35	767.0	106.1	0.822	0.889	1.082	0.890	0.922	1.958	78.5
30.00	12712.	9479.	137.4	62.33	822.5	113.7	0.822	0.885	1.077	0.890	0.919	1.958	81.2
31.00	14084.	10502.	146.9	66.62	881.8	122.0	0.822	0.882	1.074	0.889	0.918	1.958	83.9
32.00	15625.	11651.	156.6	71.02	947.3	131.0	0.822	0.876	1.066	0.890	0.916	1.958	86.6
33.00	17377.	12958.	167.5	75.96	1019.8	141.0	0.822	0.870	1.058	0.891	0.914	1.956	89.5
34.00	19391.	14460.	180.1	81.68	1101.4	152.3	0.822	0.863	1.051	0.891	0.912	1.952	92.5
35.00	21715.	16193.	194.9	88.40	1192.7	165.0	0.821	0.860	1.046	0.892	0.911	1.944	95.6
36.00	24429.	18217.	212.9	96.59	1296.8	179.3	0.821	0.858	1.045	0.891	0.910	1.931	98.9
37.00	27593.	20576.	234.5	106.39	1414.6	195.6	0.821	0.858	1.046	0.889	0.909	1.913	102.4
38.00	31320.	23356.	260.1	117.97	1548.2	214.1	0.820	0.860	1.049	0.888	0.911	1.892	106.3
39.00	35749.	26658.	289.3	131.22	1700.8	235.2	0.820	0.862	1.050	0.890	0.914	1.872	110.4
40.00	40983.	30561.	321.1	145.67	1873.9	259.2	0.820	0.860	1.049	0.894	0.919	1.854	114.9
41.00	47193.	35192.	355.1	161.07	2070.8	286.4	0.820	0.855	1.042	0.903	0.925	1.842	119.7
42.00	54621.	40731.	390.7	177.24	2293.7	317.2	0.821	0.847	1.032	0.918	0.936	1.837	125.1

Table A13. HSS HCRSP Powering Prediction, Exp93, Fully Appended, LITE Displacement, F:A RPM = 1:1

HSS-HCRSP Exp93 FA+Flap+BK LITE 1:1

LENGTH (LWL)	976.4 FT (297.6 M)
DISPLACEMENT	32845.8 TONS (33371.4 TONNES)
WETTED SURFACE	107649.4 SQ FT (10001.0 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED (KNOTS)	SHIP SPEED (M/SEC)	EFFECTIVE POWER (HP)	EFFECTIVE POWER (KW)	DELIVERED POWER (HP)	DELIVERED POWER (KW)	ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
15.0	7.72	7381.	5504.	10559.	7874.	0.699	0.791	0.868	0.768	2.335	1.413	0.922
16.0	8.23	8704.	6491.	11877.	8857.	0.733	0.787	0.899	0.787	2.269	1.402	0.867
17.0	8.75	10144.	7564.	13477.	10050.	0.753	0.784	0.906	0.801	2.205	1.392	0.812
18.0	9.26	11720.	8740.	15634.	11658.	0.750	0.783	0.893	0.811	2.146	1.383	0.763
19.0	9.77	13461.	10038.	18280.	13631.	0.736	0.783	0.871	0.816	2.095	1.374	0.721
20.0	10.29	15401.	11485.	21400.	15958.	0.720	0.783	0.848	0.818	2.055	1.366	0.690
21.0	10.80	17577.	13107.	24929.	18589.	0.705	0.783	0.827	0.820	2.026	1.358	0.668
22.0	11.32	20021.	14930.	28795.	21473.	0.695	0.783	0.813	0.821	2.008	1.351	0.657
23.0	11.83	22755.	16968.	32941.	24564.	0.691	0.783	0.806	0.821	1.997	1.344	0.653
24.0	12.35	25789.	19231.	36855.	27483.	0.700	0.783	0.810	0.822	1.992	1.337	0.655
25.0	12.86	29117.	21713.	41140.	30678.	0.708	0.783	0.813	0.823	1.990	1.331	0.659
26.0	13.38	32720.	24399.	45600.	34004.	0.718	0.783	0.820	0.825	1.988	1.325	0.663
27.0	13.89	36577.	27275.	50465.	37631.	0.725	0.783	0.825	0.826	1.984	1.319	0.665
28.0	14.40	40667.	30325.	55994.	41754.	0.726	0.783	0.825	0.828	1.978	1.314	0.664
29.0	14.92	44991.	33550.	61847.	46120.	0.727	0.783	0.824	0.831	1.970	1.308	0.661
30.0	15.43	49580.	36972.	68217.	50869.	0.727	0.783	0.822	0.834	1.961	1.303	0.657
31.0	15.95	54513.	40650.	75263.	56124.	0.724	0.783	0.819	0.837	1.954	1.298	0.655
32.0	16.46	59930.	44690.	82709.	61676.	0.725	0.783	0.817	0.840	1.953	1.294	0.659
33.0	16.98	66033.	49241.	91096.	67930.	0.725	0.783	0.816	0.842	1.962	1.289	0.673
34.0	17.49	73094.	54506.	100905.	75245.	0.724	0.783	0.813	0.844	1.986	1.285	0.701
35.0	18.01	81432.	60724.	112448.	83852.	0.724	0.783	0.811	0.846	2.028	1.280	0.747
36.0	18.52	91399.	68156.	126248.	94143.	0.724	0.783	0.808	0.847	2.092	1.276	0.815
37.0	19.03	103335.	77057.	142987.	106625.	0.723	0.783	0.805	0.848	2.178	1.272	0.906
38.0	19.55	117520.	87635.	163209.	121705.	0.720	0.782	0.802	0.847	2.287	1.269	1.018
39.0	20.06	134122.	100015.	187932.	140141.	0.714	0.781	0.798	0.846	2.414	1.265	1.149
40.0	20.58	153138.	114195.	218418.	162874.	0.701	0.780	0.791	0.844	2.555	1.261	1.294
41.0	21.09	174352.	130014.	255908.	190830.	0.681	0.779	0.781	0.841	2.701	1.258	1.443
42.0	21.61	197330.	147149.	302720.	225738.	0.652	0.779	0.767	0.839	2.844	1.254	1.589

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A13. HSS HCRSP Powering Prediction, Exp93, Fully Appended, LITE Displacement, F:A RPM = 1:1 - continued

HSS-HCRSP Exp93 FA+Flap+BK LITE 1:1

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3319.	2475.	50.6	22.96	410.7	56.8	0.746	0.706	0.946	1.005	0.980	1.673	42.4
16.00	3818.	2847.	56.3	25.54	447.4	61.9	0.746	0.721	0.967	0.995	0.981	1.674	44.8
17.00	4357.	3249.	62.2	28.23	485.8	67.2	0.746	0.734	0.984	0.985	0.978	1.674	47.1
18.00	5060.	3774.	68.4	31.05	536.6	74.2	0.746	0.732	0.981	0.979	0.972	1.677	49.5
19.00	5904.	4403.	75.1	34.04	595.9	82.4	0.746	0.724	0.971	0.977	0.965	1.680	52.0
20.00	6888.	5136.	82.0	37.20	662.3	91.6	0.746	0.713	0.957	0.976	0.958	1.684	54.6
21.00	7990.	5958.	89.4	40.54	733.4	101.4	0.746	0.703	0.944	0.976	0.952	1.687	57.2
22.00	9184.	6848.	97.3	44.13	805.6	111.4	0.745	0.698	0.937	0.976	0.950	1.690	59.9
23.00	10457.	7798.	105.9	48.04	878.4	121.5	0.745	0.697	0.936	0.976	0.948	1.691	62.5
24.00	11554.	8616.	114.9	52.11	931.2	128.8	0.745	0.714	0.958	0.975	0.958	1.692	65.2
25.00	12793.	9540.	124.4	56.41	991.0	137.1	0.745	0.726	0.974	0.974	0.964	1.692	67.8
26.00	14079.	10499.	134.0	60.79	1049.9	145.2	0.745	0.739	0.991	0.973	0.970	1.692	70.4
27.00	15525.	11577.	144.1	65.35	1116.1	154.4	0.745	0.748	1.003	0.972	0.973	1.693	73.1
28.00	17261.	12872.	154.1	69.88	1198.6	165.8	0.745	0.745	0.999	0.971	0.971	1.694	75.6
29.00	19096.	14240.	164.1	74.45	1281.8	177.3	0.745	0.743	0.997	0.971	0.970	1.696	78.2
30.00	21116.	15746.	174.4	79.11	1370.9	189.6	0.745	0.739	0.992	0.972	0.969	1.699	80.9
31.00	23376.	17432.	185.3	84.06	1469.5	203.2	0.745	0.734	0.985	0.973	0.967	1.700	83.5
32.00	25699.	19164.	197.4	89.53	1565.1	216.4	0.745	0.734	0.985	0.973	0.967	1.700	86.2
33.00	28316.	21115.	211.2	95.78	1671.2	231.1	0.745	0.734	0.985	0.972	0.966	1.698	89.0
34.00	31398.	23413.	227.2	103.04	1795.5	248.3	0.745	0.733	0.984	0.971	0.965	1.694	91.8
35.00	35040.	26129.	246.8	111.95	1939.8	268.3	0.746	0.734	0.984	0.970	0.963	1.685	94.9
36.00	39396.	29378.	270.4	122.64	2109.5	291.7	0.746	0.734	0.984	0.968	0.961	1.673	98.1
37.00	44695.	33329.	299.0	135.62	2312.3	319.8	0.745	0.733	0.984	0.965	0.958	1.657	101.5
38.00	51096.	38102.	333.3	151.17	2548.4	352.4	0.744	0.733	0.985	0.964	0.957	1.638	105.3
39.00	58929.	43943.	373.6	169.45	2828.4	391.2	0.742	0.731	0.984	0.963	0.955	1.617	109.4
40.00	68610.	51163.	419.2	190.15	3159.1	436.9	0.740	0.725	0.980	0.967	0.957	1.598	114.1
41.00	80421.	59970.	469.4	212.93	3538.2	489.3	0.738	0.719	0.974	0.979	0.964	1.584	119.4
42.00	95236.	71018.	522.2	236.86	3989.2	551.7	0.738	0.707	0.959	1.000	0.976	1.579	125.4

Table A13. HSS HCRSP Powering Prediction, Exp93, Fully Appended, LITE Displacement, F:A RPM = 1:1 - continued

HSS-HCRSP Exp93 FA+Flap+BK LITE 1:1

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1961.	1462.	53.7	24.37	242.7	33.6	0.836	1.030	1.231	0.816	0.929	1.718	42.4
16.00	2121.	1582.	56.3	25.54	248.6	34.4	0.827	1.077	1.302	0.826	0.954	1.757	44.8
17.00	2381.	1776.	59.1	26.79	265.6	36.7	0.823	1.079	1.311	0.834	0.957	1.792	47.1
18.00	2756.	2055.	62.4	28.31	292.4	40.4	0.821	1.053	1.283	0.842	0.952	1.824	49.5
19.00	3236.	2413.	66.4	30.13	326.7	45.2	0.820	1.017	1.240	0.850	0.943	1.849	52.0
20.00	3812.	2843.	71.3	32.34	366.8	50.7	0.820	0.982	1.197	0.855	0.933	1.866	54.6
21.00	4475.	3337.	76.9	34.87	411.0	56.8	0.820	0.951	1.159	0.859	0.923	1.878	57.2
22.00	5214.	3888.	83.2	37.74	457.7	63.3	0.820	0.928	1.131	0.861	0.915	1.886	59.8
23.00	6013.	4484.	90.4	40.99	505.4	69.9	0.820	0.914	1.114	0.862	0.909	1.889	62.5
24.00	6873.	5125.	98.0	44.47	554.1	76.6	0.820	0.905	1.103	0.862	0.905	1.890	65.1
25.00	7777.	5799.	106.1	48.14	602.7	83.4	0.820	0.901	1.098	0.860	0.901	1.890	67.8
26.00	8721.	6503.	114.6	51.96	650.4	90.0	0.820	0.901	1.098	0.860	0.901	1.890	70.4
27.00	9707.	7239.	123.2	55.87	698.2	96.6	0.820	0.903	1.100	0.858	0.900	1.890	73.0
28.00	10736.	8006.	131.6	59.70	745.6	103.1	0.820	0.904	1.102	0.858	0.901	1.893	75.6
29.00	11827.	8820.	140.1	63.56	794.1	109.8	0.820	0.905	1.104	0.859	0.901	1.896	78.2
30.00	12993.	9689.	148.4	67.33	844.1	116.7	0.820	0.905	1.103	0.861	0.903	1.902	80.8
31.00	14255.	10630.	157.1	71.25	896.6	124.0	0.821	0.904	1.102	0.863	0.904	1.907	83.5
32.00	15656.	11674.	166.0	75.31	953.9	131.9	0.821	0.901	1.098	0.865	0.904	1.913	86.2
33.00	17232.	12850.	176.0	79.85	1017.2	140.7	0.821	0.897	1.093	0.867	0.905	1.916	89.0
34.00	19055.	14209.	187.7	85.15	1089.8	150.7	0.821	0.893	1.088	0.869	0.904	1.915	91.8
35.00	21184.	15797.	201.4	91.37	1173.2	162.3	0.821	0.888	1.082	0.870	0.903	1.911	94.8
36.00	23728.	17694.	217.9	98.86	1271.2	175.8	0.820	0.883	1.076	0.870	0.902	1.903	98.0
37.00	26798.	19984.	237.7	107.84	1386.7	191.8	0.820	0.877	1.070	0.871	0.902	1.891	101.5
38.00	30509.	22750.	261.4	118.55	1522.2	210.5	0.820	0.872	1.063	0.873	0.901	1.876	105.3
39.00	35037.	26127.	289.1	131.15	1682.0	232.6	0.820	0.865	1.055	0.876	0.903	1.860	109.4
40.00	40599.	30274.	320.2	145.25	1869.8	258.6	0.820	0.856	1.043	0.884	0.906	1.847	114.0
41.00	47533.	35446.	354.2	160.68	2092.8	289.4	0.821	0.842	1.027	0.898	0.913	1.839	119.3
42.00	56123.	41851.	390.6	177.16	2352.1	325.3	0.821	0.827	1.007	0.922	0.927	1.840	125.3

Table A14. HSS HCRSP Powering Prediction, Exp79, Fully Appended, DES Displacement, F:A RPM = 1.05:1

HSS-HCRSP Exp79 FA+Flap+BK DES 1.05:1

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED (KNOTS)	SHIP SPEED (M/SEC)	EFFECTIVE POWER (HP)	EFFECTIVE POWER (KW)	DELIVERED POWER (HP)	DELIVERED POWER (KW)	ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
15.0	7.72	7390.	5511.	10567.	7880.	0.699	0.775	0.840	0.874	2.255	1.413	0.842
16.0	8.23	8807.	6567.	11832.	8823.	0.744	0.776	0.865	0.882	2.214	1.402	0.812
17.0	8.75	10401.	7756.	13621.	10157.	0.764	0.777	0.861	0.890	2.180	1.392	0.788
18.0	9.26	12186.	9087.	15969.	11908.	0.763	0.776	0.845	0.896	2.152	1.383	0.769
19.0	9.77	14116.	10526.	18787.	14010.	0.751	0.774	0.826	0.902	2.119	1.374	0.745
20.0	10.29	16264.	12128.	22075.	16461.	0.737	0.774	0.807	0.905	2.093	1.366	0.728
21.0	10.80	18625.	13889.	25758.	19207.	0.723	0.774	0.792	0.908	2.071	1.358	0.713
22.0	11.32	21232.	15833.	29746.	22182.	0.714	0.774	0.782	0.910	2.053	1.350	0.703
23.0	11.83	24110.	17979.	34060.	25399.	0.708	0.774	0.775	0.910	2.041	1.343	0.697
24.0	12.35	27276.	20340.	38563.	28756.	0.707	0.775	0.774	0.910	2.032	1.337	0.695
25.0	12.86	30726.	22912.	43240.	32244.	0.711	0.775	0.775	0.909	2.025	1.331	0.694
26.0	13.38	34441.	25683.	48144.	35901.	0.715	0.775	0.779	0.909	2.018	1.325	0.693
27.0	13.89	38391.	28628.	53209.	39678.	0.722	0.775	0.783	0.907	2.008	1.319	0.690
28.0	14.40	42545.	31726.	58578.	43682.	0.726	0.775	0.787	0.906	1.996	1.313	0.682
29.0	14.92	46891.	34967.	64274.	47929.	0.730	0.775	0.789	0.904	1.980	1.308	0.672
30.0	15.43	51459.	38373.	70369.	52474.	0.731	0.775	0.790	0.903	1.963	1.303	0.660
31.0	15.95	56335.	42009.	77117.	57506.	0.731	0.775	0.789	0.901	1.947	1.298	0.649
32.0	16.46	61687.	46000.	84688.	63152.	0.728	0.775	0.786	0.899	1.939	1.293	0.645
33.0	16.98	67770.	50536.	93431.	69672.	0.725	0.775	0.783	0.898	1.942	1.289	0.653
34.0	17.49	74926.	55872.	103570.	77232.	0.723	0.775	0.780	0.897	1.963	1.284	0.679
35.0	18.01	83558.	62309.	115685.	86267.	0.722	0.775	0.777	0.897	2.007	1.280	0.727
36.0	18.52	94100.	70170.	130211.	97098.	0.723	0.774	0.776	0.897	2.077	1.276	0.801
37.0	19.03	106949.	79752.	147873.	110269.	0.723	0.773	0.775	0.897	2.174	1.272	0.902
38.0	19.55	122400.	91274.	169325.	126266.	0.723	0.772	0.774	0.898	2.297	1.268	1.029
39.0	20.06	140564.	104819.	195904.	146086.	0.718	0.771	0.769	0.899	2.440	1.265	1.175
40.0	20.58	161309.	120288.	228288.	170234.	0.707	0.770	0.763	0.901	2.595	1.261	1.334
41.0	21.09	184243.	137390.	268527.	200241.	0.686	0.769	0.753	0.902	2.753	1.258	1.495
42.0	21.61	209306.	156079.	317734.	236934.	0.659	0.768	0.741	0.904	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A14. HSS HCRSP Powering Prediction, Exp79, Fully Appended, DES Displacement, F:A RPM = 1.05:1 - continued

HSS-HCRSP Exp79 FA+Flap+BK DES 1.05:1

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3817.	2846.	55.4	25.11	461.6	63.8	0.745	0.677	0.910	1.015	0.967	1.651	43.4
16.00	4226.	3151.	60.5	27.45	485.6	67.2	0.745	0.707	0.949	1.005	0.981	1.658	45.7
17.00	4824.	3597.	66.4	30.11	528.0	73.0	0.745	0.714	0.958	0.995	0.975	1.660	48.0
18.00	5621.	4191.	73.1	33.14	585.2	80.9	0.745	0.710	0.953	0.989	0.967	1.662	50.4
19.00	6584.	4910.	80.2	36.36	651.7	90.1	0.745	0.701	0.941	0.988	0.961	1.666	53.1
20.00	7715.	5753.	88.0	39.91	726.8	100.5	0.745	0.691	0.928	0.988	0.954	1.669	55.8
21.00	8989.	6703.	96.3	43.70	807.0	111.6	0.745	0.683	0.916	0.989	0.949	1.672	58.5
22.00	10367.	7731.	105.3	47.74	888.4	122.9	0.745	0.679	0.911	0.990	0.948	1.674	61.3
23.00	11865.	8848.	114.9	52.14	972.6	134.5	0.745	0.677	0.909	0.990	0.947	1.675	64.1
24.00	13423.	10010.	125.1	56.75	1055.0	145.9	0.745	0.679	0.912	0.990	0.948	1.674	66.8
25.00	15032.	11210.	135.9	61.62	1135.6	157.1	0.745	0.685	0.919	0.988	0.950	1.673	69.5
26.00	16719.	12467.	146.8	66.60	1216.6	168.3	0.745	0.690	0.926	0.985	0.951	1.672	72.2
27.00	18457.	13764.	158.2	71.78	1296.4	179.3	0.745	0.697	0.936	0.981	0.952	1.669	74.8
28.00	20298.	15136.	169.6	76.92	1378.0	190.6	0.745	0.703	0.943	0.979	0.953	1.669	77.4
29.00	22244.	16588.	180.9	82.08	1461.5	202.1	0.745	0.707	0.949	0.977	0.954	1.669	79.9
30.00	24319.	18135.	192.5	87.31	1549.0	214.2	0.745	0.710	0.952	0.974	0.953	1.669	82.5
31.00	26623.	19853.	204.5	92.75	1644.0	227.4	0.745	0.711	0.954	0.973	0.952	1.670	85.1
32.00	29208.	21780.	217.5	98.66	1749.2	241.9	0.745	0.710	0.953	0.971	0.951	1.670	87.7
33.00	32210.	24019.	232.4	105.40	1870.6	258.7	0.745	0.709	0.951	0.970	0.948	1.668	90.4
34.00	35679.	26606.	250.0	113.42	2007.6	277.7	0.745	0.708	0.951	0.969	0.947	1.662	93.3
35.00	39865.	29728.	271.6	123.21	2171.4	300.3	0.745	0.708	0.950	0.967	0.943	1.653	96.4
36.00	44895.	33478.	298.2	135.28	2362.2	326.7	0.744	0.709	0.952	0.965	0.942	1.640	99.8
37.00	51025.	38050.	331.2	150.23	2589.1	358.1	0.743	0.710	0.956	0.963	0.941	1.622	103.5
38.00	58509.	43630.	370.1	167.88	2856.4	395.0	0.741	0.710	0.959	0.963	0.941	1.603	107.6
39.00	67840.	50588.	415.3	188.38	3178.5	439.6	0.738	0.707	0.958	0.965	0.941	1.582	112.1
40.00	79228.	59081.	466.0	211.38	3550.8	491.1	0.736	0.703	0.955	0.973	0.946	1.565	117.2
41.00	93430.	69670.	521.5	236.55	3993.7	552.3	0.734	0.694	0.946	0.988	0.953	1.553	122.9
42.00	******	82669.	580.0	263.08	4508.3	623.5	0.733	0.682	0.930	1.011	0.963	1.549	129.2

Table A14. HSS HCRSP Powering Prediction, Exp79, Fully Appended, DES Displacement, F:A RPM = 1.05:1 - continued

HSS-HCRSP Exp79 FA+Flap+BK DES 1.05:1

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1466.	1093.	36.5	16.55	186.2	25.8	0.804	1.003	1.248	0.876	0.983	1.892	41.4
16.00	1690.	1260.	41.2	18.70	203.9	28.2	0.807	1.024	1.268	0.855	0.973	1.871	43.5
17.00	1986.	1481.	45.7	20.72	228.5	31.6	0.809	1.008	1.247	0.840	0.956	1.863	45.7
18.00	2363.	1762.	50.0	22.68	258.6	35.8	0.807	0.981	1.216	0.839	0.941	1.874	48.0
19.00	2810.	2095.	54.1	24.53	292.2	40.4	0.804	0.951	1.183	0.847	0.931	1.898	50.5
20.00	3322.	2477.	58.4	26.48	328.7	45.5	0.803	0.924	1.151	0.856	0.924	1.922	53.1
21.00	3890.	2901.	62.8	28.50	366.7	50.7	0.803	0.901	1.122	0.866	0.919	1.943	55.7
22.00	4506.	3360.	67.6	30.67	405.5	56.1	0.803	0.884	1.101	0.873	0.916	1.960	58.4
23.00	5165.	3852.	72.8	33.02	444.8	61.5	0.804	0.873	1.087	0.878	0.914	1.972	61.0
24.00	5858.	4368.	78.4	35.56	483.7	66.9	0.804	0.868	1.080	0.881	0.914	1.980	63.6
25.00	6588.	4913.	84.4	38.26	522.9	72.3	0.804	0.866	1.077	0.882	0.913	1.984	66.2
26.00	7353.	5483.	90.6	41.10	561.9	77.7	0.805	0.867	1.078	0.882	0.913	1.987	68.7
27.00	8147.	6076.	97.1	44.04	600.9	83.1	0.805	0.870	1.081	0.881	0.913	1.989	71.2
28.00	8991.	6705.	103.8	47.07	641.1	88.7	0.805	0.871	1.083	0.879	0.911	1.990	73.7
29.00	9893.	7377.	110.4	50.08	682.9	94.4	0.805	0.872	1.083	0.877	0.909	1.992	76.1
30.00	10865.	8102.	117.1	53.13	726.6	100.5	0.805	0.870	1.081	0.877	0.908	1.995	78.5
31.00	11935.	8900.	124.2	56.34	774.1	107.1	0.805	0.867	1.077	0.876	0.905	1.997	81.0
32.00	13136.	9796.	131.7	59.76	826.5	114.3	0.805	0.862	1.071	0.875	0.902	1.998	83.5
33.00	14506.	10817.	140.2	63.61	885.0	122.4	0.805	0.857	1.064	0.875	0.900	1.997	86.1
34.00	16106.	12010.	150.1	68.09	952.1	131.7	0.805	0.851	1.057	0.875	0.898	1.994	88.9
35.00	17977.	13406.	162.1	73.52	1028.2	142.2	0.804	0.847	1.053	0.875	0.897	1.986	91.8
36.00	20210.	15071.	176.6	80.09	1117.4	154.5	0.804	0.843	1.049	0.874	0.896	1.972	95.0
37.00	22911.	17085.	194.0	87.99	1221.0	168.9	0.803	0.840	1.047	0.874	0.898	1.955	98.6
38.00	26154.	19503.	214.4	97.25	1341.4	185.5	0.803	0.837	1.042	0.875	0.901	1.934	102.4
39.00	30112.	22455.	237.8	107.84	1481.6	204.9	0.803	0.831	1.036	0.880	0.907	1.915	106.7
40.00	34915.	26036.	263.2	119.41	1643.5	227.3	0.804	0.824	1.026	0.891	0.916	1.901	111.6
41.00	40834.	30450.	290.3	131.69	1833.9	253.6	0.804	0.813	1.011	0.909	0.928	1.897	116.9
42.00	48006.	35798.	318.4	144.44	2050.2	283.5	0.803	0.801	0.997	0.937	0.946	1.906	123.0

Table A15. HSS HCRSP Powering Prediction, Exp82, Fully Appended, DES Displacement, F:A RPM = 1.025:1

HSS-HCRSP Exp82 FA+Flap+BK DES 1.025:1

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	7390.	5511.	10152.	7570.	0.728	0.772	0.859	0.852	2.255	1.413	0.842
16.0	8.23	8807.	6567.	11479.	8560.	0.767	0.772	0.896	0.857	2.214	1.402	0.812
17.0	8.75	10401.	7756.	13322.	9934.	0.781	0.772	0.898	0.863	2.180	1.392	0.788
18.0	9.26	12186.	9087.	15689.	11700.	0.777	0.773	0.884	0.869	2.152	1.383	0.769
19.0	9.77	14116.	10526.	18467.	13771.	0.764	0.774	0.859	0.874	2.119	1.374	0.745
20.0	10.29	16264.	12128.	21714.	16192.	0.749	0.775	0.837	0.879	2.093	1.366	0.728
21.0	10.80	18625.	13889.	25341.	18897.	0.735	0.775	0.817	0.882	2.071	1.358	0.713
22.0	11.32	21232.	15833.	29288.	21840.	0.725	0.776	0.802	0.884	2.053	1.350	0.703
23.0	11.83	24110.	17979.	33556.	25023.	0.718	0.776	0.792	0.886	2.041	1.343	0.697
24.0	12.35	27276.	20340.	38046.	28371.	0.717	0.777	0.788	0.886	2.032	1.337	0.695
25.0	12.86	30726.	22912.	42816.	31928.	0.718	0.777	0.786	0.886	2.025	1.331	0.694
26.0	13.38	34441.	25683.	47856.	35686.	0.720	0.777	0.787	0.885	2.018	1.325	0.693
27.0	13.89	38391.	28628.	53113.	39606.	0.723	0.778	0.789	0.884	2.008	1.319	0.690
28.0	14.40	42545.	31726.	58694.	43768.	0.725	0.778	0.791	0.883	1.996	1.313	0.682
29.0	14.92	46891.	34967.	64726.	48266.	0.724	0.778	0.791	0.881	1.980	1.308	0.672
30.0	15.43	51459.	38373.	71225.	53112.	0.722	0.778	0.790	0.880	1.963	1.303	0.660
31.0	15.95	56335.	42009.	78332.	58412.	0.719	0.779	0.788	0.879	1.947	1.298	0.649
32.0	16.46	61687.	46000.	86331.	64377.	0.715	0.779	0.785	0.878	1.939	1.293	0.645
33.0	16.98	67770.	50536.	95347.	71100.	0.711	0.779	0.782	0.878	1.942	1.289	0.653
34.0	17.49	74926.	55872.	105812.	78904.	0.708	0.779	0.779	0.878	1.963	1.284	0.679
35.0	18.01	83558.	62309.	118041.	88023.	0.708	0.779	0.777	0.880	2.007	1.280	0.727
36.0	18.52	94100.	70170.	132358.	98700.	0.711	0.778	0.777	0.882	2.077	1.276	0.801
37.0	19.03	106949.	79752.	149505.	111486.	0.715	0.777	0.778	0.884	2.174	1.272	0.902
38.0	19.55	122400.	91274.	169743.	126578.	0.721	0.775	0.779	0.888	2.297	1.268	1.029
39.0	20.06	140564.	104819.	195123.	145503.	0.720	0.773	0.779	0.889	2.440	1.265	1.175
40.0	20.58	161309.	120288.	226264.	168725.	0.713	0.770	0.777	0.891	2.595	1.261	1.334
41.0	21.09	184243.	137390.	265844.	198240.	0.693	0.770	0.771	0.892	2.753	1.258	1.495
42.0	21.61	209306.	156079.	313642.	233882.	0.667	0.770	0.762	0.893	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A15. HSS HCRSP Powering Prediction, Exp82, Fully Appended, DES Displacement, F:A RPM = 1.025:1 - continued

HSS-HCRSP Exp82 FA+Flap+BK DES 1.025:1

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3359.	2505.	52.5	23.83	407.7	56.4	0.745	0.738	0.990	1.025	1.021	1.674	43.3
16.00	3796.	2831.	58.1	26.35	435.6	60.3	0.745	0.766	1.028	1.020	1.031	1.679	45.8
17.00	4400.	3281.	64.1	29.06	479.3	66.3	0.745	0.769	1.033	1.013	1.026	1.682	48.2
18.00	5172.	3857.	70.5	31.99	535.0	74.0	0.745	0.760	1.021	1.010	1.018	1.686	50.8
19.00	6074.	4529.	77.3	35.06	599.5	82.9	0.745	0.744	0.999	1.003	1.003	1.687	53.2
20.00	7133.	5319.	84.6	38.38	670.8	92.8	0.745	0.729	0.979	1.002	0.993	1.690	55.9
21.00	8315.	6200.	92.5	41.96	746.9	103.3	0.745	0.717	0.962	0.999	0.984	1.691	58.5
22.00	9599.	7158.	101.1	45.84	825.0	114.1	0.745	0.709	0.952	0.997	0.977	1.691	61.1
23.00	10999.	8202.	110.2	49.98	906.4	125.3	0.745	0.703	0.944	0.994	0.970	1.690	63.7
24.00	12466.	9296.	120.2	54.54	986.8	136.5	0.745	0.703	0.944	0.990	0.966	1.687	66.4
25.00	14043.	10472.	130.7	59.29	1069.6	147.9	0.745	0.704	0.945	0.986	0.962	1.684	69.0
26.00	15712.	11717.	141.8	64.32	1152.8	159.4	0.745	0.707	0.949	0.982	0.960	1.680	71.6
27.00	17450.	13013.	153.2	69.50	1235.8	170.9	0.745	0.711	0.955	0.978	0.959	1.677	74.2
28.00	19304.	14395.	164.8	74.77	1320.5	182.6	0.745	0.715	0.960	0.975	0.958	1.675	76.8
29.00	21314.	15894.	176.6	80.10	1410.2	195.0	0.745	0.717	0.963	0.973	0.957	1.674	79.4
30.00	23476.	17506.	188.3	85.43	1503.2	207.9	0.745	0.718	0.964	0.972	0.956	1.675	82.0
31.00	25842.	19270.	200.6	90.99	1602.2	221.6	0.745	0.718	0.963	0.972	0.956	1.675	84.7
32.00	28506.	21257.	213.4	96.79	1711.2	236.7	0.745	0.715	0.960	0.973	0.956	1.677	87.5
33.00	31492.	23483.	227.9	103.39	1831.0	253.2	0.745	0.714	0.958	0.974	0.956	1.676	90.3
34.00	34947.	26060.	244.9	111.10	1967.5	272.1	0.745	0.712	0.956	0.974	0.955	1.672	93.3
35.00	38973.	29062.	265.0	120.19	2122.8	293.6	0.745	0.711	0.955	0.974	0.954	1.666	96.4
36.00	43646.	32547.	289.3	131.24	2299.1	318.0	0.745	0.713	0.957	0.973	0.953	1.655	99.7
37.00	49240.	36718.	318.6	144.54	2504.4	346.4	0.744	0.714	0.960	0.972	0.953	1.641	103.3
38.00	55839.	41639.	353.2	160.20	2740.8	379.1	0.743	0.716	0.963	0.971	0.952	1.624	107.0
39.00	64126.	47819.	393.6	178.54	3022.8	418.1	0.742	0.716	0.966	0.975	0.957	1.608	111.4
40.00	74131.	55279.	438.6	198.96	3343.0	462.3	0.740	0.716	0.967	0.986	0.968	1.596	116.5
41.00	86907.	64807.	486.8	220.82	3729.1	515.7	0.740	0.711	0.961	1.009	0.987	1.593	122.4
42.00	******	76211.	537.7	243.92	4161.5	575.5	0.740	0.706	0.953	1.041	1.013	1.596	129.0

Table A15. HSS HCRSP Powering Prediction, Exp82, Fully Appended, DES Displacement, F:A RPM = 1.025:1 - continued

HSS-HCRSP Exp82 FA+Flap+BK DES 1.025:1

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1717.	1280.	41.7	18.91	213.7	29.6	0.799	0.981	1.227	0.878	0.968	1.858	42.2
16.00	1943.	1449.	46.6	21.14	228.7	31.6	0.799	1.025	1.282	0.870	0.976	1.858	44.6
17.00	2261.	1686.	51.5	23.36	252.5	34.9	0.800	1.027	1.284	0.865	0.970	1.862	47.0
18.00	2672.	1993.	56.4	25.58	283.5	39.2	0.801	1.008	1.257	0.864	0.960	1.872	49.5
19.00	3159.	2356.	61.1	27.73	319.7	44.2	0.803	0.974	1.213	0.863	0.944	1.882	51.9
20.00	3723.	2777.	66.1	29.99	359.1	49.7	0.805	0.944	1.174	0.867	0.934	1.895	54.5
21.00	4356.	3248.	71.3	32.35	401.1	55.5	0.806	0.918	1.138	0.870	0.924	1.907	57.0
22.00	5046.	3763.	76.8	34.83	444.8	61.5	0.807	0.896	1.110	0.872	0.916	1.917	59.6
23.00	5779.	4309.	82.6	37.46	488.4	67.5	0.808	0.881	1.090	0.874	0.910	1.926	62.2
24.00	6557.	4889.	88.9	40.30	532.2	73.6	0.809	0.872	1.079	0.874	0.906	1.931	64.7
25.00	7365.	5492.	95.3	43.21	575.2	79.5	0.809	0.868	1.072	0.874	0.903	1.936	67.3
26.00	8216.	6127.	102.0	46.27	618.4	85.5	0.810	0.866	1.070	0.874	0.902	1.940	69.8
27.00	9106.	6790.	108.8	49.34	661.2	91.4	0.810	0.866	1.069	0.875	0.902	1.945	72.3
28.00	10044.	7490.	115.6	52.43	704.8	97.5	0.811	0.866	1.068	0.875	0.902	1.950	74.8
29.00	11049.	8239.	122.4	55.53	749.6	103.7	0.811	0.865	1.066	0.877	0.903	1.957	77.4
30.00	12137.	9050.	129.3	58.64	797.0	110.2	0.812	0.862	1.062	0.879	0.903	1.964	80.0
31.00	13324.	9936.	136.3	61.84	847.2	117.2	0.812	0.859	1.057	0.882	0.904	1.972	82.6
32.00	14659.	10932.	144.2	65.41	902.5	124.8	0.812	0.855	1.052	0.885	0.905	1.977	85.3
33.00	16182.	12067.	153.1	69.43	964.8	133.4	0.813	0.850	1.046	0.888	0.905	1.980	88.1
34.00	17959.	13392.	163.8	74.30	1036.4	143.3	0.812	0.846	1.041	0.889	0.905	1.978	91.0
35.00	20048.	14949.	177.1	80.35	1119.9	154.9	0.812	0.843	1.038	0.889	0.904	1.970	94.0
36.00	22534.	16803.	193.6	87.81	1217.1	168.3	0.811	0.842	1.038	0.887	0.902	1.955	97.2
37.00	25513.	19025.	213.9	97.02	1331.1	184.1	0.809	0.841	1.040	0.884	0.901	1.935	100.7
38.00	29032.	21649.	238.1	108.01	1460.7	202.0	0.807	0.843	1.045	0.881	0.901	1.910	104.4
39.00	33436.	24933.	266.9	121.08	1616.4	223.6	0.803	0.842	1.048	0.881	0.904	1.884	108.6
40.00	39001.	29083.	299.2	135.72	1804.0	249.5	0.800	0.837	1.046	0.889	0.911	1.865	113.5
41.00	46015.	34313.	334.3	151.65	2024.0	279.9	0.799	0.830	1.038	0.908	0.927	1.856	119.4
42.00	54621.	40731.	371.8	168.64	2281.1	315.5	0.799	0.818	1.024	0.932	0.945	1.854	125.8

Table A16. HSS HCRSP Powering Prediction, Exp81, Fully Appended, DES Displacement, F:A RPM = 0.975:1

HSS-HCRSP Exp81 FA+Flap+BK DES 0.975:1

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	7390.	5511.	10576.	7886.	0.699	0.776	0.823	0.818	2.255	1.413	0.842
16.0	8.23	8807.	6567.	12152.	9062.	0.725	0.775	0.828	0.831	2.214	1.402	0.812
17.0	8.75	10401.	7756.	14132.	10538.	0.736	0.775	0.823	0.843	2.180	1.392	0.788
18.0	9.26	12186.	9087.	16497.	12302.	0.739	0.776	0.813	0.856	2.152	1.383	0.769
19.0	9.77	14116.	10526.	19236.	14344.	0.734	0.777	0.801	0.865	2.119	1.374	0.745
20.0	10.29	16264.	12128.	22319.	16643.	0.729	0.778	0.792	0.873	2.093	1.366	0.728
21.0	10.80	18625.	13889.	25887.	19304.	0.719	0.779	0.781	0.878	2.071	1.358	0.713
22.0	11.32	21232.	15833.	29549.	22035.	0.719	0.779	0.787	0.881	2.053	1.350	0.703
23.0	11.83	24110.	17979.	33879.	25263.	0.712	0.780	0.778	0.883	2.041	1.343	0.697
24.0	12.35	27276.	20340.	38324.	28578.	0.712	0.781	0.777	0.884	2.032	1.337	0.695
25.0	12.86	30726.	22912.	42941.	32021.	0.716	0.781	0.780	0.884	2.025	1.331	0.694
26.0	13.38	34441.	25683.	47929.	35740.	0.719	0.781	0.783	0.883	2.018	1.325	0.693
27.0	13.89	38391.	28628.	53123.	39614.	0.723	0.781	0.788	0.882	2.008	1.319	0.690
28.0	14.40	42545.	31726.	58598.	43696.	0.726	0.782	0.792	0.880	1.996	1.313	0.682
29.0	14.92	46891.	34967.	64434.	48048.	0.728	0.782	0.795	0.879	1.980	1.308	0.672
30.0	15.43	51459.	38373.	70927.	52890.	0.726	0.782	0.795	0.877	1.963	1.303	0.660
31.0	15.95	56335.	42009.	78070.	58217.	0.722	0.782	0.792	0.876	1.947	1.298	0.649
32.0	16.46	61687.	46000.	85783.	63968.	0.719	0.782	0.791	0.876	1.939	1.293	0.645
33.0	16.98	67770.	50536.	94683.	70605.	0.716	0.783	0.787	0.875	1.942	1.289	0.653
34.0	17.49	74926.	55872.	104894.	78219.	0.714	0.783	0.785	0.876	1.963	1.284	0.679
35.0	18.01	83558.	62309.	116875.	87153.	0.715	0.783	0.784	0.878	2.007	1.280	0.727
36.0	18.52	94100.	70170.	131007.	97692.	0.718	0.782	0.784	0.880	2.077	1.276	0.801
37.0	19.03	106949.	79752.	147992.	110358.	0.723	0.782	0.784	0.883	2.174	1.272	0.902
38.0	19.55	122400.	91274.	167166.	124656.	0.732	0.781	0.784	0.887	2.297	1.268	1.029
39.0	20.06	140564.	104819.	189611.	141393.	0.741	0.779	0.791	0.891	2.440	1.265	1.175
40.0	20.58	161309.	120288.	216715.	161604.	0.744	0.777	0.794	0.897	2.595	1.261	1.334
41.0	21.09	184243.	137390.	247329.	184433.	0.745	0.775	0.794	0.901	2.753	1.258	1.495
42.0	21.61	209306.	156079.	282425.	210604.	0.741	0.774	0.799	0.906	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A16. HSS HCRSP Powering Prediction, Exp81, Fully Appended, DES Displacement, F:A RPM = 0.975:1 - continued

HSS-HCRSP Exp81 FA+Flap+BK DES 0.975:1

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3142.	2343.	50.8	23.05	389.8	53.9	0.745	0.744	0.999	1.000	0.999	1.669	42.3
16.00	3563.	2657.	54.8	24.87	419.5	58.0	0.745	0.752	1.010	0.995	0.999	1.682	44.6
17.00	4114.	3068.	59.5	26.98	460.3	63.7	0.745	0.748	1.005	0.992	0.994	1.692	46.9
18.00	4783.	3566.	64.7	29.36	508.3	70.3	0.744	0.741	0.996	0.991	0.989	1.700	49.4
19.00	5566.	4151.	70.5	31.96	562.4	77.8	0.744	0.732	0.984	0.992	0.986	1.708	52.0
20.00	6464.	4820.	76.9	34.86	621.9	86.0	0.743	0.724	0.974	0.992	0.982	1.712	54.6
21.00	7510.	5600.	83.9	38.07	689.4	95.3	0.743	0.714	0.961	0.992	0.977	1.715	57.2
22.00	8817.	6575.	91.5	41.52	773.0	106.9	0.743	0.696	0.937	0.993	0.968	1.717	59.9
23.00	10113.	7541.	99.9	45.31	849.1	117.4	0.743	0.691	0.930	0.991	0.964	1.717	62.6
24.00	11422.	8517.	108.8	49.35	919.5	127.2	0.743	0.695	0.935	0.990	0.965	1.716	65.2
25.00	12781.	9531.	118.4	53.68	988.9	136.8	0.743	0.702	0.945	0.988	0.967	1.714	67.9
26.00	14279.	10648.	128.3	58.21	1064.1	147.2	0.743	0.706	0.950	0.985	0.966	1.712	70.5
27.00	15838.	11810.	138.4	62.78	1137.9	157.4	0.743	0.712	0.958	0.983	0.967	1.711	73.1
28.00	17494.	13045.	148.8	67.49	1214.1	167.9	0.743	0.717	0.964	0.981	0.967	1.709	75.7
29.00	19249.	14354.	159.3	72.25	1292.1	178.7	0.744	0.721	0.969	0.979	0.967	1.709	78.2
30.00	21264.	15857.	169.8	77.02	1381.3	191.0	0.743	0.719	0.967	0.978	0.965	1.709	80.9
31.00	23473.	17504.	180.8	82.00	1477.3	204.3	0.743	0.716	0.963	0.977	0.963	1.710	83.5
32.00	25832.	19263.	192.5	87.30	1575.0	217.8	0.743	0.715	0.962	0.977	0.963	1.710	86.1
33.00	28475.	21234.	205.8	93.34	1682.5	232.7	0.744	0.715	0.961	0.977	0.962	1.708	88.9
34.00	31588.	23555.	221.4	100.41	1808.5	250.1	0.744	0.714	0.959	0.976	0.960	1.704	91.7
35.00	35227.	26269.	240.1	108.92	1952.4	270.0	0.744	0.714	0.959	0.975	0.959	1.696	94.8
36.00	39538.	29483.	263.2	119.40	2119.5	293.1	0.745	0.716	0.961	0.973	0.957	1.685	98.0
37.00	44711.	33341.	291.1	132.03	2315.9	320.3	0.745	0.718	0.963	0.971	0.955	1.669	101.4
38.00	49355.	36804.	324.4	147.13	2466.0	341.0	0.745	0.743	0.997	0.969	0.968	1.651	105.1
39.00	56316.	41995.	362.5	164.43	2707.8	374.5	0.744	0.748	1.005	0.970	0.973	1.632	109.2
40.00	64524.	48115.	404.6	183.53	2979.9	412.1	0.742	0.750	1.011	0.975	0.980	1.616	113.7
41.00	73815.	55044.	450.3	204.25	3277.7	453.3	0.741	0.751	1.014	0.979	0.986	1.599	118.3
42.00	84398.	62935.	498.1	225.96	3584.5	495.7	0.740	0.757	1.023	0.995	1.006	1.591	123.7

Table A16. HSS HCRSP Powering Prediction, Exp81, Fully Appended, DES Displacement, F:A RPM = 0.975:1 - continued

HSS-HCRSP Exp81 FA+Flap+BK DES 0.975:1

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	2146.	1600.	47.3	21.44	259.6	35.9	0.807	0.901	1.117	0.889	0.949	1.829	43.4
16.00	2513.	1874.	53.1	24.07	288.7	39.9	0.806	0.904	1.122	0.872	0.936	1.818	45.7
17.00	2951.	2201.	58.7	26.63	322.1	44.6	0.806	0.897	1.113	0.864	0.924	1.819	48.1
18.00	3466.	2584.	64.1	29.09	359.3	49.7	0.808	0.885	1.096	0.866	0.916	1.833	50.7
19.00	4052.	3021.	69.4	31.48	399.4	55.2	0.810	0.871	1.075	0.872	0.910	1.852	53.3
20.00	4695.	3501.	74.9	33.99	440.8	61.0	0.812	0.861	1.059	0.878	0.908	1.870	55.9
21.00	5433.	4052.	80.7	36.62	486.2	67.2	0.815	0.848	1.041	0.886	0.906	1.888	58.7
22.00	5957.	4442.	86.9	39.41	509.4	70.4	0.816	0.878	1.075	0.891	0.924	1.901	61.4
23.00	6826.	5090.	93.5	42.43	558.8	77.3	0.817	0.866	1.059	0.895	0.921	1.911	64.2
24.00	7740.	5772.	100.6	45.65	607.8	84.1	0.818	0.860	1.051	0.898	0.920	1.919	66.9
25.00	8689.	6480.	108.2	49.10	656.0	90.7	0.819	0.859	1.049	0.899	0.919	1.923	69.6
26.00	9685.	7222.	116.2	52.69	704.0	97.4	0.819	0.860	1.050	0.899	0.920	1.926	72.3
27.00	10724.	7997.	124.3	56.38	751.7	104.0	0.819	0.864	1.054	0.899	0.922	1.930	74.9
28.00	11805.	8803.	132.4	60.05	799.0	110.5	0.820	0.868	1.058	0.900	0.924	1.935	77.6
29.00	12968.	9670.	140.6	63.77	849.0	117.4	0.820	0.869	1.059	0.901	0.925	1.939	80.2
30.00	14200.	10589.	148.8	67.50	899.9	124.5	0.821	0.870	1.060	0.902	0.926	1.945	82.9
31.00	15562.	11605.	157.2	71.29	955.4	132.1	0.821	0.868	1.058	0.904	0.927	1.951	85.6
32.00	17059.	12721.	166.2	75.38	1014.5	140.3	0.821	0.867	1.055	0.906	0.928	1.956	88.3
33.00	18867.	14069.	176.5	80.05	1087.5	150.4	0.822	0.860	1.046	0.907	0.926	1.957	91.1
34.00	20859.	15555.	188.4	85.45	1164.8	161.1	0.822	0.856	1.042	0.909	0.925	1.956	94.1
35.00	23211.	17308.	203.0	92.09	1255.0	173.6	0.821	0.853	1.039	0.908	0.924	1.949	97.1
36.00	25966.	19363.	220.7	100.10	1358.0	187.8	0.820	0.852	1.039	0.908	0.924	1.938	100.4
37.00	29285.	21838.	242.0	109.78	1479.7	204.6	0.819	0.851	1.039	0.906	0.924	1.922	103.9
38.00	34228.	25524.	267.5	121.33	1668.1	230.7	0.816	0.825	1.011	0.905	0.911	1.901	107.8
39.00	38490.	28702.	296.3	134.40	1805.9	249.8	0.814	0.835	1.026	0.906	0.920	1.880	111.9
40.00	43834.	32687.	328.2	148.87	1975.3	273.2	0.811	0.838	1.032	0.911	0.929	1.863	116.5
41.00	49849.	37173.	362.1	164.25	2159.4	298.6	0.809	0.838	1.035	0.916	0.938	1.846	121.2
42.00	56815.	42367.	397.6	180.37	2354.9	325.7	0.809	0.841	1.040	0.933	0.958	1.841	126.7

Table A17. HSS HCRSP Powering Prediction, Exp80, Fully Appended, DES Displacement, F:A RPM = 0.95:1

HSS-HCRSP Exp80 FA+Flap+BK DES 0.95:1

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	7390.	5511.	10628.	7926.	0.695	0.895	0.858	0.836	2.255	1.413	0.842
16.0	8.23	8807.	6567.	12632.	9420.	0.697	0.948	0.861	0.838	2.214	1.402	0.812
17.0	8.75	10401.	7756.	14838.	11064.	0.701	0.948	0.852	0.845	2.180	1.392	0.788
18.0	9.26	12186.	9087.	17248.	12862.	0.707	0.915	0.836	0.857	2.152	1.383	0.769
19.0	9.77	14116.	10526.	19883.	14826.	0.710	0.872	0.819	0.869	2.119	1.374	0.745
20.0	10.29	16264.	12128.	22744.	16960.	0.715	0.841	0.808	0.880	2.093	1.366	0.728
21.0	10.80	18625.	13889.	26208.	19543.	0.711	0.830	0.808	0.869	2.071	1.358	0.713
22.0	11.32	21232.	15833.	29914.	22307.	0.710	0.813	0.796	0.878	2.053	1.350	0.703
23.0	11.83	24110.	17979.	33722.	25146.	0.715	0.805	0.794	0.884	2.041	1.343	0.697
24.0	12.35	27276.	20340.	37895.	28258.	0.720	0.800	0.794	0.888	2.032	1.337	0.695
25.0	12.86	30726.	22912.	42448.	31653.	0.724	0.798	0.794	0.890	2.025	1.331	0.694
26.0	13.38	34441.	25683.	47430.	35368.	0.726	0.798	0.796	0.890	2.018	1.325	0.693
27.0	13.89	38391.	28628.	52832.	39397.	0.727	0.798	0.796	0.888	2.008	1.319	0.690
28.0	14.40	42545.	31726.	58754.	43813.	0.724	0.798	0.795	0.886	1.996	1.313	0.682
29.0	14.92	46891.	34967.	65238.	48648.	0.719	0.798	0.791	0.882	1.980	1.308	0.672
30.0	15.43	51459.	38373.	72362.	53961.	0.711	0.798	0.786	0.879	1.963	1.303	0.660
31.0	15.95	56335.	42009.	80302.	59881.	0.702	0.798	0.779	0.875	1.947	1.298	0.649
32.0	16.46	61687.	46000.	88720.	66158.	0.695	0.797	0.775	0.872	1.939	1.293	0.645
33.0	16.98	67770.	50536.	98306.	73307.	0.689	0.798	0.771	0.870	1.942	1.289	0.653
34.0	17.49	74926.	55872.	108700.	81057.	0.689	0.801	0.772	0.869	1.963	1.284	0.679
35.0	18.01	83558.	62309.	119763.	89307.	0.698	0.807	0.780	0.870	2.007	1.280	0.727
36.0	18.52	94100.	70170.	133344.	99435.	0.706	0.820	0.794	0.864	2.077	1.276	0.801
37.0	19.03	106949.	79752.	148710.	110893.	0.719	0.839	0.812	0.862	2.174	1.272	0.902
38.0	19.55	122400.	91274.	166051.	123824.	0.737	0.871	0.839	0.857	2.297	1.268	1.029
39.0	20.06	140564.	104819.	186201.	138850.	0.755	0.908	0.869	0.851	2.440	1.265	1.175
40.0	20.58	161309.	120288.	210331.	156844.	0.767	0.947	0.887	0.848	2.595	1.261	1.334
41.0	21.09	184243.	137390.	236753.	176546.	0.778	0.964	0.880	0.862	2.753	1.258	1.495
42.0	21.61	209306.	156079.	265374.	197889.	0.789	0.970	0.884	0.861	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A17. HSS HCRSP Powering Prediction, Exp80, Fully Appended, DES Displacement, F:A RPM = 0.95:1 - continued

HSS-HCRSP Exp80 FA+Flap+BK DES 0.95:1

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3064.	2285.	46.8	21.22	382.6	52.9	0.744	0.712	0.957	1.013	0.995	1.701	42.1
16.00	3574.	2665.	50.4	22.85	422.6	58.5	0.743	0.700	0.942	1.012	0.989	1.717	44.4
17.00	4160.	3102.	54.8	24.87	466.3	64.5	0.742	0.694	0.936	1.010	0.986	1.726	46.9
18.00	4820.	3595.	60.1	27.25	513.2	71.0	0.741	0.693	0.935	1.007	0.982	1.731	49.3
19.00	5557.	4144.	65.6	29.78	562.8	77.8	0.741	0.692	0.935	1.005	0.981	1.735	51.9
20.00	6383.	4760.	71.9	32.59	615.9	85.2	0.740	0.694	0.937	1.004	0.981	1.738	54.4
21.00	7391.	5511.	81.0	36.74	680.4	94.1	0.742	0.704	0.949	0.996	0.977	1.727	57.1
22.00	8452.	6303.	88.1	39.98	744.4	103.0	0.741	0.700	0.945	0.995	0.975	1.729	59.6
23.00	9537.	7112.	95.8	43.48	805.3	111.4	0.741	0.704	0.950	0.993	0.974	1.729	62.2
24.00	10722.	7995.	104.0	47.19	869.1	120.2	0.741	0.708	0.955	0.991	0.975	1.729	64.8
25.00	12002.	8950.	112.6	51.09	935.6	129.4	0.742	0.712	0.960	0.989	0.975	1.729	67.4
26.00	13391.	9985.	121.5	55.12	1004.8	139.0	0.741	0.715	0.965	0.988	0.975	1.729	70.0
27.00	14880.	11096.	130.6	59.24	1077.1	149.0	0.741	0.717	0.967	0.986	0.975	1.729	72.6
28.00	16516.	12316.	139.6	63.30	1154.1	159.6	0.741	0.716	0.966	0.986	0.974	1.730	75.2
29.00	18288.	13638.	148.7	67.44	1234.6	170.7	0.741	0.714	0.963	0.987	0.974	1.733	77.8
30.00	20259.	15107.	157.9	71.62	1322.8	182.9	0.741	0.709	0.957	0.988	0.973	1.735	80.4
31.00	22391.	16697.	167.7	76.05	1415.6	195.8	0.740	0.704	0.951	0.988	0.971	1.737	83.1
32.00	24714.	18429.	178.3	80.86	1512.8	209.2	0.740	0.701	0.947	0.989	0.971	1.738	85.8
33.00	27459.	20477.	190.3	86.34	1629.0	225.3	0.740	0.694	0.938	0.989	0.967	1.737	88.5
34.00	30458.	22712.	205.2	93.07	1751.8	242.3	0.741	0.694	0.937	0.987	0.964	1.732	91.3
35.00	33638.	25084.	223.0	101.17	1875.1	259.3	0.742	0.701	0.945	0.985	0.964	1.723	94.2
36.00	37700.	28113.	248.8	112.84	2036.2	281.6	0.744	0.712	0.957	0.977	0.960	1.704	97.2
37.00	42373.	31597.	279.3	126.71	2216.5	306.5	0.745	0.724	0.972	0.968	0.956	1.680	100.4
38.00	47812.	35654.	318.8	144.63	2421.2	334.8	0.745	0.741	0.996	0.953	0.952	1.646	103.7
39.00	54314.	40502.	366.6	166.28	2658.1	367.6	0.743	0.757	1.019	0.937	0.948	1.605	107.3
40.00	61662.	45982.	421.2	191.06	2918.3	403.6	0.740	0.769	1.039	0.918	0.942	1.558	111.0
41.00	69789.	52042.	471.2	213.72	3207.1	443.5	0.739	0.763	1.033	0.899	0.927	1.519	114.3
42.00	78686.	58676.	536.3	243.27	3494.4	483.3	0.740	0.771	1.042	0.878	0.926	1.468	118.3

Table A17. HSS HCRSP Powering Prediction, Exp80, Fully Appended, DES Displacement, F:A RPM = 0.95:1 - continued

HSS-HCRSP Exp80 FA+Flap+BK DES 0.95:1

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	2250.	1678.	49.2	22.34	267.0	36.9	1.045	1.005	0.961	0.997	0.984	2.013	44.3
16.00	2742.	2045.	56.7	25.71	308.1	42.6	1.152	1.021	0.886	1.006	0.967	2.051	46.7
17.00	3258.	2430.	63.1	28.62	347.2	48.0	1.154	1.009	0.874	0.999	0.959	2.051	49.3
18.00	3803.	2836.	68.7	31.16	384.8	53.2	1.088	0.979	0.900	0.982	0.954	2.028	51.9
19.00	4384.	3269.	73.7	33.44	421.8	58.3	1.004	0.946	0.942	0.964	0.951	1.999	54.6
20.00	4989.	3720.	78.8	35.73	457.6	63.3	0.941	0.923	0.981	0.953	0.950	1.981	57.3
21.00	5713.	4260.	85.3	38.69	500.0	69.1	0.918	0.912	0.994	0.948	0.949	1.976	60.0
22.00	6505.	4851.	91.0	41.28	544.4	75.3	0.885	0.891	1.007	0.944	0.948	1.970	62.8
23.00	7324.	5461.	97.4	44.17	587.5	81.2	0.868	0.883	1.018	0.941	0.948	1.969	65.5
24.00	8226.	6134.	104.5	47.40	633.5	87.6	0.859	0.879	1.023	0.940	0.948	1.970	68.2
25.00	9221.	6876.	112.4	50.97	683.1	94.5	0.855	0.877	1.025	0.938	0.946	1.970	70.9
26.00	10324.	7699.	121.0	54.88	736.4	101.8	0.854	0.876	1.025	0.937	0.945	1.970	73.6
27.00	11536.	8602.	130.2	59.04	793.5	109.7	0.854	0.875	1.023	0.935	0.943	1.970	76.4
28.00	12861.	9591.	139.9	63.45	853.9	118.1	0.855	0.873	1.021	0.935	0.942	1.970	79.1
29.00	14331.	10687.	149.9	67.98	919.5	127.2	0.856	0.869	1.015	0.934	0.940	1.970	81.9
30.00	15922.	11873.	160.1	72.61	988.0	136.6	0.855	0.864	1.010	0.933	0.938	1.970	84.6
31.00	17760.	13244.	170.8	77.46	1067.0	147.6	0.855	0.853	0.998	0.933	0.935	1.970	87.4
32.00	19646.	14650.	182.0	82.54	1142.9	158.1	0.855	0.849	0.993	0.933	0.935	1.970	90.3
33.00	21693.	16177.	194.3	88.14	1223.2	169.2	0.857	0.847	0.988	0.934	0.935	1.970	93.1
34.00	23892.	17816.	208.0	94.36	1305.7	180.6	0.861	0.849	0.986	0.935	0.936	1.969	96.1
35.00	26243.	19569.	224.1	101.64	1390.6	192.3	0.871	0.859	0.985	0.936	0.937	1.969	99.1
36.00	28972.	21604.	244.2	110.77	1486.8	205.6	0.896	0.876	0.979	0.941	0.941	1.972	102.3
37.00	31982.	23849.	267.0	121.10	1590.1	219.9	0.934	0.900	0.963	0.949	0.944	1.980	105.6
38.00	35213.	26258.	293.9	133.29	1694.8	234.4	0.998	0.937	0.939	0.963	0.950	1.997	109.1
39.00	38787.	28923.	323.4	146.68	1804.1	249.5	1.073	0.981	0.914	0.983	0.958	2.022	112.9
40.00	43503.	32440.	354.0	160.59	1956.6	270.6	1.153	1.004	0.871	1.005	0.965	2.051	116.8
41.00	48587.	36232.	378.6	171.73	2122.5	293.5	1.188	0.996	0.839	1.016	0.970	2.064	120.2
42.00	54001.	40268.	406.4	184.34	2280.2	315.3	1.200	0.998	0.831	1.029	0.981	2.069	124.4

Table A18. HSS HCRSP Powering Prediction, Exp84, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Steering Angle of LE 5 degrees to Starboard

HSS-HCRSP Exp84 FA+Flap+BK DES 5degTurn

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	7390.	5511.	12050.	8986.	0.613	0.783	0.812	0.773	2.255	1.413	0.842
16.0	8.23	8807.	6567.	13792.	10284.	0.639	0.783	0.825	0.784	2.214	1.402	0.812
17.0	8.75	10401.	7756.	16072.	11985.	0.647	0.783	0.824	0.794	2.180	1.392	0.788
18.0	9.26	12186.	9087.	18860.	14064.	0.646	0.783	0.814	0.802	2.152	1.383	0.769
19.0	9.77	14116.	10526.	22083.	16468.	0.639	0.783	0.801	0.807	2.119	1.374	0.745
20.0	10.29	16264.	12128.	25736.	19192.	0.632	0.783	0.788	0.812	2.093	1.366	0.728
21.0	10.80	18625.	13889.	29751.	22186.	0.626	0.783	0.779	0.814	2.071	1.358	0.713
22.0	11.32	21232.	15833.	34107.	25434.	0.623	0.783	0.773	0.815	2.053	1.350	0.703
23.0	11.83	24110.	17979.	38730.	28881.	0.623	0.783	0.771	0.815	2.041	1.343	0.697
24.0	12.35	27276.	20340.	43664.	32560.	0.625	0.783	0.771	0.815	2.032	1.337	0.695
25.0	12.86	30726.	22912.	48892.	36459.	0.628	0.783	0.774	0.813	2.025	1.331	0.694
26.0	13.38	34441.	25683.	54406.	40571.	0.633	0.783	0.778	0.811	2.018	1.325	0.693
27.0	13.89	38391.	28628.	60233.	44916.	0.637	0.783	0.782	0.810	2.008	1.319	0.690
28.0	14.40	42545.	31726.	66352.	49479.	0.641	0.783	0.786	0.808	1.996	1.313	0.682
29.0	14.92	46891.	34967.	73064.	54484.	0.642	0.783	0.787	0.807	1.980	1.308	0.672
30.0	15.43	51459.	38373.	80310.	59887.	0.641	0.783	0.787	0.805	1.963	1.303	0.660
31.0	15.95	56335.	42009.	88281.	65831.	0.638	0.783	0.785	0.804	1.947	1.298	0.649
32.0	16.46	61687.	46000.	97194.	72478.	0.635	0.783	0.782	0.804	1.939	1.293	0.645
33.0	16.98	67770.	50536.	107363.	80061.	0.631	0.783	0.778	0.804	1.942	1.289	0.653
34.0	17.49	74926.	55872.	119001.	88739.	0.630	0.783	0.775	0.805	1.963	1.284	0.679
35.0	18.01	83558.	62309.	132656.	98922.	0.630	0.783	0.773	0.807	2.007	1.280	0.727
36.0	18.52	94100.	70170.	148508.	110742.	0.634	0.783	0.774	0.809	2.077	1.276	0.801
37.0	19.03	106949.	79752.	167450.	124868.	0.639	0.782	0.775	0.812	2.174	1.272	0.902
38.0	19.55	122400.	91274.	189821.	141550.	0.645	0.782	0.777	0.817	2.297	1.268	1.029
39.0	20.06	140564.	104819.	216661.	161564.	0.649	0.780	0.777	0.821	2.440	1.265	1.175
40.0	20.58	161309.	120288.	248563.	185353.	0.649	0.779	0.775	0.826	2.595	1.261	1.334
41.0	21.09	184243.	137390.	287521.	214404.	0.641	0.778	0.769	0.831	2.753	1.258	1.495
42.0	21.61	209306.	156079.	334260.	249258.	0.626	0.777	0.759	0.836	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A18. HSS HCRSP Powering Prediction, Exp84, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Steering Angle of LE 5 degrees to Starboard - continued

HSS-HCRSP Exp84 FA+Flap+BK DES 5degTurn

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3956.	2950.	56.5	25.61	474.6	65.6	0.745	0.671	0.901	1.022	0.968	1.649	43.8
16.00	4484.	3344.	61.6	27.94	509.0	70.4	0.745	0.688	0.923	1.020	0.981	1.661	46.3
17.00	5200.	3878.	67.6	30.68	558.3	77.2	0.746	0.692	0.929	1.020	0.986	1.671	48.9
18.00	6093.	4544.	74.4	33.76	620.4	85.8	0.746	0.688	0.922	1.019	0.982	1.675	51.6
19.00	7129.	5316.	81.7	37.05	689.8	95.4	0.746	0.681	0.913	1.019	0.977	1.680	54.3
20.00	8315.	6200.	89.6	40.66	766.2	106.0	0.746	0.673	0.903	1.018	0.971	1.682	57.0
21.00	9620.	7174.	98.0	44.47	846.3	117.0	0.746	0.667	0.895	1.016	0.965	1.684	59.7
22.00	11035.	8229.	107.3	48.65	928.3	128.4	0.746	0.666	0.893	1.014	0.962	1.684	62.4
23.00	12531.	9345.	117.0	53.06	1010.7	139.8	0.746	0.666	0.893	1.011	0.959	1.682	65.1
24.00	14118.	10528.	127.4	57.77	1093.9	151.3	0.746	0.669	0.897	1.007	0.958	1.680	67.8
25.00	15806.	11786.	138.3	62.73	1178.5	163.0	0.746	0.673	0.903	1.003	0.956	1.677	70.4
26.00	17572.	13103.	149.5	67.80	1262.8	174.6	0.746	0.678	0.910	1.000	0.956	1.675	73.1
27.00	19429.	14488.	160.9	72.98	1347.8	186.4	0.746	0.684	0.917	0.996	0.957	1.674	75.7
28.00	21358.	15927.	172.2	78.09	1431.2	197.9	0.746	0.689	0.924	0.995	0.960	1.675	78.4
29.00	23492.	17518.	183.5	83.22	1522.7	210.6	0.746	0.691	0.927	0.994	0.960	1.676	81.0
30.00	25781.	19225.	194.9	88.40	1617.2	223.7	0.746	0.692	0.928	0.994	0.962	1.679	83.7
31.00	28281.	21089.	206.5	93.66	1717.8	237.6	0.746	0.692	0.928	0.996	0.963	1.682	86.5
32.00	31092.	23185.	219.3	99.49	1828.5	252.9	0.746	0.691	0.927	0.998	0.965	1.684	89.3
33.00	34297.	25575.	233.7	105.99	1954.7	270.3	0.746	0.689	0.923	0.998	0.963	1.684	92.2
34.00	37995.	28333.	250.7	113.74	2096.8	290.0	0.746	0.688	0.922	0.999	0.963	1.681	95.2
35.00	42372.	31597.	271.6	123.21	2262.1	312.8	0.746	0.688	0.922	0.999	0.962	1.674	98.4
36.00	47429.	35368.	297.4	134.91	2450.0	338.8	0.745	0.690	0.926	0.996	0.960	1.661	101.7
37.00	53582.	39956.	328.9	149.18	2673.6	369.8	0.744	0.692	0.930	0.993	0.958	1.645	105.3
38.00	60835.	45365.	366.5	166.24	2928.9	405.1	0.743	0.695	0.936	0.990	0.956	1.624	109.1
39.00	69586.	51890.	410.7	186.28	3228.5	446.5	0.740	0.697	0.941	0.986	0.953	1.601	113.2
40.00	80014.	59667.	459.5	208.42	3568.2	493.5	0.738	0.696	0.944	0.988	0.954	1.580	117.8
41.00	92864.	69249.	512.7	232.58	3972.1	549.3	0.735	0.690	0.939	0.994	0.955	1.564	122.8
42.00	******	80786.	569.4	258.28	4434.4	613.3	0.734	0.682	0.930	1.007	0.959	1.552	128.3

Table A18. HSS HCRSP Powering Prediction, Exp84, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Steering Angle of LE 5 degrees to Starboard - continued

HSS-HCRSP Exp84 FA+Flap+BK DES 5degTurn

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	2069.	1543.	47.4	21.52	248.2	34.3	0.820	0.953	1.161	0.903	0.976	1.843	43.8
16.00	2412.	1798.	52.8	23.93	273.9	37.9	0.820	0.962	1.172	0.895	0.971	1.845	46.2
17.00	2836.	2115.	57.9	26.26	304.6	42.1	0.820	0.955	1.165	0.897	0.969	1.858	48.9
18.00	3337.	2488.	63.1	28.62	339.9	47.0	0.820	0.941	1.147	0.900	0.964	1.872	51.6
19.00	3912.	2917.	68.2	30.95	378.6	52.4	0.820	0.921	1.123	0.906	0.959	1.888	54.3
20.00	4553.	3395.	73.6	33.39	419.6	58.0	0.820	0.904	1.101	0.911	0.954	1.903	57.0
21.00	5255.	3919.	79.4	36.02	462.3	63.9	0.821	0.890	1.084	0.914	0.950	1.915	59.7
22.00	6018.	4488.	85.7	38.89	506.6	70.1	0.821	0.880	1.073	0.915	0.947	1.922	62.4
23.00	6834.	5096.	92.6	42.01	551.6	76.3	0.821	0.876	1.067	0.915	0.944	1.927	65.1
24.00	7714.	5752.	100.0	45.35	598.1	82.7	0.821	0.873	1.063	0.914	0.942	1.930	67.7
25.00	8641.	6443.	108.0	48.99	644.6	89.2	0.821	0.875	1.066	0.912	0.940	1.929	70.4
26.00	9631.	7182.	116.5	52.86	692.5	95.8	0.821	0.878	1.069	0.909	0.939	1.928	73.0
27.00	10688.	7970.	125.2	56.80	741.5	102.5	0.821	0.881	1.073	0.908	0.938	1.928	75.7
28.00	11818.	8813.	134.1	60.83	792.4	109.6	0.821	0.883	1.075	0.905	0.937	1.927	78.3
29.00	13040.	9724.	143.2	64.95	845.4	116.9	0.821	0.884	1.077	0.905	0.937	1.929	81.0
30.00	14374.	10719.	152.2	69.05	902.1	124.8	0.821	0.882	1.074	0.905	0.935	1.931	83.7
31.00	15860.	11827.	161.6	73.31	963.7	133.3	0.821	0.878	1.069	0.906	0.934	1.934	86.4
32.00	17505.	13053.	171.4	77.77	1029.9	142.4	0.821	0.873	1.063	0.908	0.934	1.938	89.3
33.00	19385.	14455.	182.6	82.85	1105.0	152.8	0.821	0.867	1.056	0.909	0.932	1.938	92.1
34.00	21506.	16037.	195.4	88.61	1187.0	164.2	0.821	0.862	1.050	0.910	0.931	1.936	95.2
35.00	23956.	17864.	210.5	95.48	1279.6	177.0	0.821	0.859	1.046	0.910	0.931	1.930	98.3
36.00	26824.	20003.	229.0	103.86	1385.8	191.7	0.821	0.858	1.045	0.910	0.930	1.918	101.7
37.00	30143.	22478.	250.8	113.75	1505.1	208.2	0.820	0.858	1.046	0.908	0.930	1.903	105.2
38.00	34076.	25410.	276.2	125.29	1641.7	227.0	0.820	0.859	1.047	0.909	0.931	1.886	109.0
39.00	38744.	28892.	304.9	138.31	1797.7	248.6	0.820	0.858	1.047	0.911	0.934	1.870	113.2
40.00	44267.	33010.	335.9	152.38	1975.3	273.2	0.820	0.855	1.042	0.918	0.939	1.857	117.7
41.00	50896.	37953.	368.7	167.23	2178.5	301.3	0.820	0.847	1.033	0.930	0.948	1.850	122.7
42.00	58794.	43843.	402.0	182.33	2407.2	332.9	0.820	0.837	1.020	0.950	0.961	1.852	128.3

Table A19. HSS HCRSP Powering Prediction, Exp85, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Steering Angle of LE 2.5 degrees to Starboard

HSS-HCRSP Exp85 FA+Flap+BK DES 2.5degTurn

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	7390.	5511.	11342.	8458.	0.652	0.784	0.844	0.775	2.255	1.413	0.842
16.0	8.23	8807.	6567.	12962.	9665.	0.679	0.783	0.853	0.796	2.214	1.402	0.812
17.0	8.75	10401.	7756.	15055.	11227.	0.691	0.783	0.849	0.814	2.180	1.392	0.788
18.0	9.26	12186.	9087.	17621.	13140.	0.692	0.783	0.837	0.827	2.152	1.383	0.769
19.0	9.77	14116.	10526.	20591.	15355.	0.686	0.783	0.820	0.837	2.119	1.374	0.745
20.0	10.29	16264.	12128.	23935.	17848.	0.680	0.783	0.806	0.844	2.093	1.366	0.728
21.0	10.80	18625.	13889.	27645.	20615.	0.674	0.783	0.795	0.847	2.071	1.358	0.713
22.0	11.32	21232.	15833.	31662.	23611.	0.671	0.783	0.788	0.849	2.053	1.350	0.703
23.0	11.83	24110.	17979.	36038.	26874.	0.669	0.783	0.783	0.849	2.041	1.343	0.697
24.0	12.35	27276.	20340.	40687.	30341.	0.670	0.783	0.783	0.847	2.032	1.337	0.695
25.0	12.86	30726.	22912.	45650.	34041.	0.673	0.783	0.783	0.845	2.025	1.331	0.694
26.0	13.38	34441.	25683.	50946.	37990.	0.676	0.783	0.785	0.842	2.018	1.325	0.693
27.0	13.89	38391.	28628.	56609.	42213.	0.678	0.783	0.788	0.839	2.008	1.319	0.690
28.0	14.40	42545.	31726.	62610.	46689.	0.680	0.783	0.789	0.836	1.996	1.313	0.682
29.0	14.92	46891.	34967.	69142.	51560.	0.678	0.783	0.789	0.833	1.980	1.308	0.672
30.0	15.43	51459.	38373.	76300.	56897.	0.674	0.783	0.787	0.831	1.963	1.303	0.660
31.0	15.95	56335.	42009.	84165.	62762.	0.669	0.783	0.783	0.829	1.947	1.298	0.649
32.0	16.46	61687.	46000.	92905.	69279.	0.664	0.783	0.778	0.829	1.939	1.293	0.645
33.0	16.98	67770.	50536.	102813.	76668.	0.659	0.783	0.773	0.829	1.942	1.289	0.653
34.0	17.49	74926.	55872.	114087.	85075.	0.657	0.783	0.770	0.830	1.963	1.284	0.679
35.0	18.01	83558.	62309.	127127.	94799.	0.657	0.783	0.768	0.833	2.007	1.280	0.727
36.0	18.52	94100.	70170.	142239.	106067.	0.662	0.783	0.769	0.837	2.077	1.276	0.801
37.0	19.03	106949.	79752.	159784.	119151.	0.669	0.783	0.772	0.842	2.174	1.272	0.902
38.0	19.55	122400.	91274.	180413.	134534.	0.678	0.782	0.776	0.847	2.297	1.268	1.029
39.0	20.06	140564.	104819.	205003.	152870.	0.686	0.781	0.777	0.854	2.440	1.265	1.175
40.0	20.58	161309.	120288.	233888.	174410.	0.690	0.780	0.777	0.862	2.595	1.261	1.334
41.0	21.09	184243.	137390.	268078.	199906.	0.687	0.779	0.772	0.870	2.753	1.258	1.495
42.0	21.61	209306.	156079.	308884.	230335.	0.678	0.778	0.763	0.877	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A19. HSS HCRSP Powering Prediction, Exp85, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Steering Angle of LE 2.5 degrees to Starboard - continued

HSS-HCRSP Exp85 FA+Flap+BK DES 2.5degTurn

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3695.	2755.	53.6	24.31	448.7	62.1	0.745	0.680	0.912	1.018	0.973	1.663	43.2
16.00	4218.	3145.	59.6	27.01	484.9	67.1	0.745	0.700	0.939	1.009	0.980	1.666	45.7
17.00	4888.	3645.	65.7	29.79	531.8	73.5	0.746	0.706	0.947	1.008	0.984	1.672	48.3
18.00	5705.	4254.	72.1	32.70	588.3	81.4	0.746	0.704	0.944	1.008	0.983	1.679	50.9
19.00	6646.	4956.	78.6	35.66	651.6	90.1	0.746	0.696	0.933	1.009	0.979	1.686	53.6
20.00	7701.	5742.	85.6	38.82	719.0	99.4	0.745	0.689	0.924	1.010	0.976	1.692	56.3
21.00	8869.	6614.	93.0	42.18	791.0	109.4	0.745	0.682	0.915	1.009	0.971	1.696	58.9
22.00	10130.	7554.	101.1	45.84	864.5	119.6	0.745	0.679	0.911	1.008	0.969	1.698	61.5
23.00	11503.	8578.	109.9	49.85	941.7	130.2	0.745	0.678	0.910	1.005	0.965	1.698	64.2
24.00	12964.	9667.	119.5	54.19	1019.5	141.0	0.745	0.680	0.912	1.002	0.963	1.696	66.8
25.00	14521.	10828.	129.5	58.75	1099.5	152.1	0.745	0.683	0.916	0.998	0.960	1.694	69.4
26.00	16185.	12069.	140.3	63.65	1181.2	163.4	0.745	0.687	0.922	0.993	0.959	1.691	72.0
27.00	17973.	13403.	151.4	68.68	1266.1	175.1	0.746	0.691	0.927	0.990	0.957	1.688	74.6
28.00	19844.	14797.	162.9	73.88	1351.1	186.9	0.746	0.695	0.933	0.986	0.957	1.686	77.1
29.00	21912.	16340.	174.5	79.14	1442.1	199.4	0.746	0.698	0.936	0.985	0.957	1.686	79.8
30.00	24182.	18032.	186.3	84.51	1540.3	213.0	0.746	0.698	0.936	0.983	0.955	1.686	82.5
31.00	26674.	19891.	198.5	90.02	1645.2	227.5	0.746	0.696	0.933	0.983	0.954	1.686	85.2
32.00	29431.	21947.	211.7	96.01	1757.5	243.1	0.746	0.695	0.932	0.984	0.954	1.686	88.0
33.00	32582.	24296.	226.4	102.69	1884.5	260.6	0.746	0.692	0.929	0.984	0.952	1.685	90.8
34.00	36161.	26965.	243.6	110.49	2024.1	279.9	0.746	0.692	0.928	0.985	0.953	1.681	93.8
35.00	40327.	30072.	264.3	119.87	2183.8	302.0	0.746	0.693	0.929	0.984	0.952	1.673	97.0
36.00	45154.	33671.	289.3	131.24	2364.6	327.0	0.745	0.696	0.933	0.983	0.951	1.661	100.3
37.00	50735.	37833.	319.1	144.73	2566.7	355.0	0.745	0.700	0.940	0.980	0.951	1.646	103.8
38.00	57303.	42731.	354.6	160.85	2797.5	386.9	0.743	0.706	0.950	0.978	0.952	1.627	107.6
39.00	65197.	48617.	394.7	179.02	3067.7	424.3	0.741	0.708	0.955	0.977	0.952	1.608	111.6
40.00	74405.	55483.	438.6	198.96	3369.9	466.1	0.739	0.708	0.958	0.978	0.955	1.590	116.0
41.00	85298.	63606.	484.9	219.95	3715.7	513.9	0.737	0.704	0.954	0.984	0.957	1.576	120.6
42.00	98358.	73346.	533.5	241.99	4114.7	569.1	0.736	0.695	0.944	0.994	0.959	1.567	125.5

Table A19. HSS HCRSP Powering Prediction, Exp85, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Steering Angle of LE 2.5 degrees to Starboard - continued

HSS-HCRSP Exp85 FA+Flap+BK DES 2.5degTurn

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1976.	1473.	50.0	22.67	240.1	33.2	0.823	1.008	1.224	0.866	0.967	1.789	43.2
16.00	2263.	1687.	53.1	24.10	260.3	36.0	0.821	1.007	1.226	0.873	0.969	1.823	45.7
17.00	2640.	1969.	56.8	25.78	287.3	39.7	0.820	0.992	1.209	0.883	0.969	1.853	48.3
18.00	3106.	2316.	61.2	27.77	320.4	44.3	0.820	0.969	1.182	0.890	0.965	1.875	50.9
19.00	3649.	2721.	66.0	29.94	357.9	49.5	0.820	0.945	1.152	0.896	0.958	1.893	53.6
20.00	4267.	3182.	71.5	32.42	398.6	55.1	0.821	0.924	1.126	0.899	0.951	1.905	56.2
21.00	4953.	3694.	77.5	35.17	441.8	61.1	0.821	0.908	1.107	0.900	0.945	1.912	58.9
22.00	5701.	4252.	84.2	38.18	486.8	67.3	0.821	0.897	1.092	0.899	0.938	1.916	61.5
23.00	6516.	4859.	91.3	41.43	533.7	73.8	0.821	0.888	1.082	0.897	0.932	1.917	64.1
24.00	7380.	5503.	99.1	44.97	580.6	80.3	0.821	0.885	1.079	0.895	0.928	1.916	66.8
25.00	8304.	6193.	107.4	48.73	628.9	87.0	0.821	0.884	1.078	0.891	0.924	1.913	69.3
26.00	9288.	6926.	115.9	52.58	678.3	93.8	0.821	0.884	1.077	0.888	0.920	1.911	71.9
27.00	10331.	7704.	124.7	56.56	728.2	100.7	0.821	0.885	1.078	0.885	0.918	1.909	74.5
28.00	11461.	8547.	133.2	60.44	780.4	107.9	0.821	0.883	1.076	0.884	0.916	1.911	77.1
29.00	12660.	9440.	141.8	64.32	833.8	115.3	0.821	0.881	1.073	0.884	0.915	1.914	79.7
30.00	13968.	10416.	150.1	68.08	890.2	123.1	0.821	0.876	1.067	0.886	0.914	1.920	82.4
31.00	15409.	11490.	158.5	71.90	950.8	131.5	0.821	0.869	1.059	0.888	0.913	1.927	85.1
32.00	17022.	12693.	167.4	75.94	1017.0	140.7	0.821	0.861	1.049	0.892	0.912	1.933	87.9
33.00	18825.	14038.	177.2	80.39	1089.1	150.6	0.821	0.853	1.039	0.895	0.912	1.938	90.8
34.00	20882.	15572.	188.8	85.63	1169.4	161.7	0.821	0.847	1.032	0.898	0.912	1.940	93.8
35.00	23236.	17327.	202.6	91.90	1258.8	174.1	0.821	0.844	1.027	0.901	0.913	1.937	97.0
36.00	25966.	19363.	219.5	99.58	1359.9	188.1	0.821	0.842	1.026	0.902	0.913	1.928	100.3
37.00	29157.	21743.	240.3	108.99	1475.4	204.0	0.821	0.844	1.028	0.902	0.914	1.914	103.8
38.00	32903.	24536.	264.8	120.11	1606.6	222.2	0.820	0.846	1.031	0.901	0.916	1.897	107.6
39.00	37305.	27818.	292.7	132.79	1756.2	242.9	0.820	0.847	1.033	0.902	0.918	1.878	111.6
40.00	42539.	31722.	324.0	146.97	1928.2	266.7	0.820	0.846	1.031	0.905	0.921	1.860	115.9
41.00	48742.	36347.	357.2	162.01	2124.0	293.8	0.820	0.841	1.025	0.912	0.926	1.848	120.5
42.00	56084.	41822.	391.9	177.76	2346.9	324.6	0.821	0.831	1.013	0.923	0.931	1.839	125.5

Table A20. HSS HCRSP Powering Prediction, Exp86, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 2.5 degrees to Inboard

HSS-HCRSP Exp86 FA+Flap+BK DES 2.5degInbd Alignment

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED (KNOTS)	SHIP SPEED (M/SEC)	EFFECTIVE POWER (HP)	EFFECTIVE POWER (KW)	DELIVERED POWER (HP)	DELIVERED POWER (KW)	ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
15.0	7.72	7390.	5511.	11217.	8365.	0.659	0.783	0.789	0.827	2.255	1.413	0.842
16.0	8.23	8807.	6567.	13074.	9749.	0.674	0.783	0.799	0.832	2.214	1.402	0.812
17.0	8.75	10401.	7756.	15292.	11403.	0.680	0.783	0.796	0.843	2.180	1.392	0.788
18.0	9.26	12186.	9087.	17884.	13336.	0.681	0.783	0.788	0.854	2.152	1.383	0.769
19.0	9.77	14116.	10526.	20817.	15523.	0.678	0.782	0.776	0.865	2.119	1.374	0.745
20.0	10.29	16264.	12128.	24107.	17977.	0.675	0.782	0.766	0.873	2.093	1.366	0.728
21.0	10.80	18625.	13889.	27706.	20660.	0.672	0.782	0.758	0.880	2.071	1.358	0.713
22.0	11.32	21232.	15833.	31620.	23579.	0.671	0.782	0.753	0.884	2.053	1.350	0.703
23.0	11.83	24110.	17979.	35859.	26740.	0.672	0.783	0.751	0.886	2.041	1.343	0.697
24.0	12.35	27276.	20340.	40451.	30165.	0.674	0.783	0.751	0.886	2.032	1.337	0.695
25.0	12.86	30726.	22912.	45348.	33816.	0.678	0.783	0.753	0.884	2.025	1.331	0.694
26.0	13.38	34441.	25683.	50644.	37765.	0.680	0.783	0.756	0.880	2.018	1.325	0.693
27.0	13.89	38391.	28628.	56380.	42043.	0.681	0.783	0.758	0.875	2.008	1.319	0.690
28.0	14.40	42545.	31726.	62597.	46678.	0.680	0.783	0.760	0.870	1.996	1.313	0.682
29.0	14.92	46891.	34967.	69395.	51748.	0.676	0.783	0.760	0.864	1.980	1.308	0.672
30.0	15.43	51459.	38373.	76912.	57354.	0.669	0.784	0.757	0.858	1.963	1.303	0.660
31.0	15.95	56335.	42009.	85219.	63548.	0.661	0.784	0.754	0.852	1.947	1.298	0.649
32.0	16.46	61687.	46000.	94499.	70468.	0.653	0.784	0.749	0.847	1.939	1.293	0.645
33.0	16.98	67770.	50536.	104978.	78282.	0.646	0.784	0.746	0.844	1.942	1.289	0.653
34.0	17.49	74926.	55872.	116935.	87198.	0.641	0.784	0.742	0.842	1.963	1.284	0.679
35.0	18.01	83558.	62309.	130624.	97406.	0.640	0.784	0.742	0.842	2.007	1.280	0.727
36.0	18.52	94100.	70170.	146488.	109236.	0.642	0.783	0.743	0.843	2.077	1.276	0.801
37.0	19.03	106949.	79752.	164711.	122825.	0.649	0.783	0.746	0.847	2.174	1.272	0.902
38.0	19.55	122400.	91274.	186054.	138740.	0.658	0.782	0.750	0.852	2.297	1.268	1.029
39.0	20.06	140564.	104819.	210672.	157098.	0.667	0.781	0.754	0.859	2.440	1.265	1.175
40.0	20.58	161309.	120288.	239653.	178710.	0.673	0.780	0.754	0.868	2.595	1.261	1.334
41.0	21.09	184243.	137390.	273524.	203967.	0.674	0.780	0.750	0.878	2.753	1.258	1.495
42.0	21.61	209306.	156079.	312870.	233307.	0.669	0.779	0.743	0.888	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A20. HSS HCRSP Powering Prediction, Exp86, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 2.5 degrees to Inboard - continued

HSS-HCRSP Exp86 FA+Flap+BK DES 2.5degInbd Alignment

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3492.	2604.	51.1	23.16	426.0	58.9	0.746	0.690	0.926	1.026	0.991	1.683	43.1
16.00	4055.	3024.	56.5	25.65	466.5	64.5	0.745	0.701	0.940	1.024	0.997	1.690	45.7
17.00	4728.	3525.	62.2	28.23	514.4	71.1	0.745	0.703	0.943	1.023	0.999	1.698	48.3
18.00	5519.	4116.	68.3	30.96	569.2	78.7	0.745	0.699	0.939	1.024	0.998	1.704	50.9
19.00	6416.	4785.	74.4	33.77	629.1	87.0	0.744	0.692	0.930	1.024	0.995	1.710	53.6
20.00	7433.	5543.	81.2	36.83	694.5	96.0	0.744	0.686	0.922	1.023	0.991	1.715	56.2
21.00	8544.	6371.	88.4	40.12	762.5	105.4	0.744	0.681	0.916	1.022	0.987	1.717	58.9
22.00	9757.	7276.	96.4	43.71	833.2	115.2	0.744	0.680	0.914	1.020	0.984	1.718	61.5
23.00	11080.	8262.	105.0	47.65	907.7	125.5	0.744	0.680	0.914	1.016	0.980	1.717	64.1
24.00	12512.	9330.	114.6	51.98	985.2	136.2	0.744	0.682	0.916	1.011	0.976	1.714	66.7
25.00	14043.	10472.	124.8	56.63	1064.0	147.1	0.744	0.686	0.922	1.006	0.974	1.710	69.3
26.00	15712.	11717.	135.7	61.57	1147.4	158.7	0.745	0.690	0.927	1.001	0.971	1.705	71.9
27.00	17514.	13060.	147.2	66.76	1234.5	170.7	0.745	0.694	0.931	0.996	0.968	1.701	74.5
28.00	19480.	14526.	158.9	72.08	1326.3	183.4	0.745	0.696	0.934	0.993	0.965	1.698	77.1
29.00	21629.	16129.	170.9	77.50	1423.5	196.9	0.745	0.696	0.934	0.990	0.962	1.695	79.8
30.00	24001.	17898.	183.1	83.07	1527.9	211.3	0.745	0.695	0.932	0.989	0.960	1.694	82.5
31.00	26623.	19853.	195.8	88.83	1640.1	226.8	0.745	0.692	0.928	0.989	0.958	1.693	85.3
32.00	29544.	22031.	209.4	94.98	1761.1	243.6	0.745	0.689	0.924	0.989	0.956	1.693	88.1
33.00	32834.	24485.	224.6	101.86	1893.5	261.9	0.745	0.686	0.921	0.991	0.956	1.691	91.1
34.00	36585.	27281.	242.0	109.75	2041.8	282.4	0.746	0.684	0.917	0.991	0.954	1.687	94.1
35.00	40880.	30484.	262.8	119.22	2205.9	305.1	0.746	0.685	0.918	0.991	0.954	1.680	97.3
36.00	45858.	34196.	287.8	130.53	2391.5	330.7	0.745	0.687	0.921	0.991	0.953	1.668	100.7
37.00	51517.	38416.	317.4	143.95	2593.9	358.7	0.745	0.692	0.929	0.990	0.955	1.654	104.3
38.00	58175.	43381.	351.8	159.56	2826.4	390.9	0.744	0.697	0.937	0.989	0.956	1.637	108.1
39.00	65807.	49072.	391.0	177.35	3083.3	426.4	0.742	0.702	0.946	0.987	0.958	1.618	112.1
40.00	74819.	55792.	433.4	196.60	3376.1	466.9	0.741	0.704	0.950	0.989	0.961	1.602	116.4
41.00	85298.	63606.	477.9	216.79	3704.1	512.3	0.739	0.701	0.949	0.995	0.965	1.589	120.9
42.00	97442.	72663.	524.5	237.93	4068.7	562.7	0.738	0.697	0.945	1.004	0.971	1.580	125.8

Table A20. HSS HCRSP Powering Prediction, Exp86, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 2.5 degrees to Inboard - continued

HSS-HCRSP Exp86 FA+Flap+BK DES 2.5degInbd Alignment

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	2116.	1578.	46.0	20.88	258.3	35.7	0.821	0.887	1.081	0.886	0.926	1.840	43.0
16.00	2482.	1851.	51.2	23.22	285.7	39.5	0.820	0.896	1.092	0.885	0.929	1.848	45.6
17.00	2918.	2176.	56.1	25.43	317.6	43.9	0.820	0.890	1.085	0.888	0.927	1.862	48.3
18.00	3423.	2553.	60.9	27.61	353.2	48.8	0.820	0.876	1.068	0.892	0.924	1.879	50.9
19.00	3992.	2977.	65.6	29.74	391.5	54.1	0.820	0.860	1.048	0.898	0.920	1.897	53.6
20.00	4620.	3445.	70.6	32.00	431.7	59.7	0.821	0.846	1.031	0.903	0.917	1.913	56.2
21.00	5309.	3959.	75.8	34.39	474.0	65.6	0.821	0.834	1.015	0.906	0.913	1.926	58.8
22.00	6052.	4513.	81.5	36.96	517.2	71.5	0.821	0.825	1.005	0.908	0.910	1.936	61.5
23.00	6849.	5108.	87.7	39.77	561.2	77.6	0.821	0.822	1.000	0.909	0.909	1.943	64.1
24.00	7714.	5752.	94.5	42.85	607.4	84.0	0.821	0.819	0.997	0.908	0.907	1.946	66.7
25.00	8631.	6436.	101.8	46.16	654.3	90.5	0.821	0.820	0.998	0.906	0.905	1.948	69.3
26.00	9610.	7166.	109.4	49.65	702.1	97.1	0.821	0.822	1.000	0.904	0.905	1.948	71.9
27.00	10676.	7961.	117.5	53.29	752.8	104.1	0.821	0.823	1.001	0.902	0.903	1.948	74.5
28.00	11818.	8813.	125.8	57.06	804.7	111.3	0.822	0.825	1.004	0.902	0.903	1.949	77.1
29.00	13069.	9745.	134.1	60.85	860.4	119.0	0.822	0.823	1.002	0.901	0.902	1.951	79.8
30.00	14455.	10779.	142.7	64.75	920.3	127.3	0.822	0.820	0.998	0.902	0.902	1.954	82.5
31.00	15986.	11921.	151.7	68.81	985.0	136.2	0.822	0.816	0.993	0.904	0.901	1.957	85.2
32.00	17706.	13203.	161.2	73.14	1055.9	146.0	0.822	0.810	0.986	0.906	0.900	1.960	88.1
33.00	19655.	14657.	171.9	77.99	1134.0	156.8	0.822	0.805	0.979	0.908	0.899	1.961	91.0
34.00	21883.	16318.	184.3	83.61	1221.4	168.9	0.822	0.800	0.974	0.910	0.899	1.959	94.1
35.00	24432.	18219.	199.3	90.39	1318.6	182.4	0.822	0.798	0.972	0.911	0.899	1.952	97.3
36.00	27386.	20422.	217.3	98.56	1428.9	197.6	0.821	0.798	0.972	0.911	0.898	1.940	100.7
37.00	30839.	22996.	238.8	108.33	1553.8	214.9	0.821	0.800	0.975	0.910	0.898	1.924	104.2
38.00	34852.	25989.	264.0	119.75	1694.5	234.3	0.821	0.803	0.979	0.909	0.899	1.904	108.0
39.00	39529.	29477.	292.7	132.79	1852.9	256.3	0.820	0.805	0.982	0.909	0.900	1.884	112.0
40.00	45008.	33563.	323.7	146.82	2032.2	281.1	0.820	0.804	0.981	0.911	0.902	1.866	116.3
41.00	51465.	38377.	356.1	161.54	2236.0	309.2	0.820	0.799	0.974	0.918	0.904	1.854	120.9
42.00	58993.	43991.	389.6	176.73	2463.7	340.7	0.820	0.790	0.963	0.928	0.907	1.846	125.8

Table A21. HSS HCRSP Powering Prediction, Exp87, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 2.5 degrees to Outboard

HSS-HCRSP Exp87 FA+Flap+BK DES 2.5degOutbd Alignment

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	7390.	5511.	11230.	8374.	0.658	0.783	0.807	0.788	2.255	1.413	0.842
16.0	8.23	8807.	6567.	12472.	9301.	0.706	0.784	0.822	0.829	2.214	1.402	0.812
17.0	8.75	10401.	7756.	14251.	10627.	0.730	0.783	0.820	0.858	2.180	1.392	0.788
18.0	9.26	12186.	9087.	16539.	12333.	0.737	0.782	0.813	0.878	2.152	1.383	0.769
19.0	9.77	14116.	10526.	19293.	14387.	0.732	0.782	0.802	0.889	2.119	1.374	0.745
20.0	10.29	16264.	12128.	22473.	16758.	0.724	0.782	0.791	0.895	2.093	1.366	0.728
21.0	10.80	18625.	13889.	26042.	19420.	0.715	0.783	0.781	0.897	2.071	1.358	0.713
22.0	11.32	21232.	15833.	29961.	22342.	0.709	0.783	0.775	0.895	2.053	1.350	0.703
23.0	11.83	24110.	17979.	34291.	25571.	0.703	0.783	0.774	0.892	2.041	1.343	0.697
24.0	12.35	27276.	20340.	38898.	29006.	0.701	0.783	0.773	0.888	2.032	1.337	0.695
25.0	12.86	30726.	22912.	43957.	32779.	0.699	0.784	0.774	0.884	2.025	1.331	0.694
26.0	13.38	34441.	25683.	49201.	36690.	0.700	0.784	0.777	0.879	2.018	1.325	0.693
27.0	13.89	38391.	28628.	54660.	40760.	0.702	0.784	0.781	0.875	2.008	1.319	0.690
28.0	14.40	42545.	31726.	60530.	45137.	0.703	0.784	0.782	0.871	1.996	1.313	0.682
29.0	14.92	46891.	34967.	66816.	49824.	0.702	0.784	0.783	0.868	1.980	1.308	0.672
30.0	15.43	51459.	38373.	73632.	54907.	0.699	0.784	0.782	0.865	1.963	1.303	0.660
31.0	15.95	56335.	42009.	81231.	60574.	0.694	0.784	0.778	0.864	1.947	1.298	0.649
32.0	16.46	61687.	46000.	89565.	66789.	0.689	0.784	0.774	0.864	1.939	1.293	0.645
33.0	16.98	67770.	50536.	99049.	73860.	0.684	0.784	0.770	0.864	1.942	1.289	0.653
34.0	17.49	74926.	55872.	109979.	82011.	0.681	0.784	0.767	0.865	1.963	1.284	0.679
35.0	18.01	83558.	62309.	122455.	91315.	0.682	0.784	0.767	0.867	2.007	1.280	0.727
36.0	18.52	94100.	70170.	136404.	101716.	0.690	0.784	0.771	0.870	2.077	1.276	0.801
37.0	19.03	106949.	79752.	153541.	114495.	0.697	0.783	0.773	0.874	2.174	1.272	0.902
38.0	19.55	122400.	91274.	173924.	129695.	0.704	0.782	0.777	0.878	2.297	1.268	1.029
39.0	20.06	140564.	104819.	198243.	147830.	0.709	0.781	0.779	0.882	2.440	1.265	1.175
40.0	20.58	161309.	120288.	227357.	169540.	0.709	0.780	0.778	0.887	2.595	1.261	1.334
41.0	21.09	184243.	137390.	262205.	195527.	0.703	0.778	0.773	0.891	2.753	1.258	1.495
42.0	21.61	209306.	156079.	304094.	226763.	0.688	0.777	0.764	0.896	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A21. HSS HCRSP Powering Prediction, Exp87, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 2.5 degrees to Outboard - continued

HSS-HCRSP Exp87 FA+Flap+BK DES 2.5degOutbd Alignment

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3615.	2696.	54.4	24.67	447.4	61.9	0.744	0.680	0.914	0.982	0.937	1.635	42.4
16.00	3904.	2911.	56.2	25.49	456.4	63.1	0.746	0.707	0.948	1.000	0.977	1.678	44.9
17.00	4400.	3281.	59.8	27.11	487.1	67.4	0.745	0.714	0.958	1.007	0.990	1.700	47.4
18.00	5086.	3793.	64.9	29.43	533.3	73.8	0.744	0.713	0.957	1.011	0.994	1.712	50.1
19.00	5951.	4438.	71.1	32.26	592.6	82.0	0.744	0.705	0.948	1.012	0.991	1.717	52.7
20.00	6974.	5201.	78.5	35.60	661.3	91.5	0.744	0.697	0.937	1.009	0.984	1.716	55.4
21.00	8140.	6070.	86.8	39.39	737.3	102.0	0.744	0.690	0.927	1.004	0.974	1.712	58.0
22.00	9428.	7031.	96.0	43.55	817.5	113.1	0.745	0.686	0.921	0.998	0.964	1.707	60.6
23.00	10860.	8099.	106.0	48.06	900.7	124.6	0.745	0.685	0.920	0.995	0.961	1.702	63.3
24.00	12353.	9212.	116.6	52.89	983.6	136.0	0.745	0.688	0.923	0.989	0.956	1.696	66.0
25.00	14043.	10472.	127.9	58.00	1074.6	148.6	0.745	0.688	0.923	0.985	0.951	1.690	68.6
26.00	15770.	11759.	139.4	63.24	1161.7	160.7	0.746	0.692	0.928	0.981	0.949	1.685	71.3
27.00	17546.	13084.	151.2	68.59	1247.6	172.5	0.746	0.697	0.934	0.976	0.947	1.680	73.9
28.00	19445.	14500.	162.9	73.88	1336.3	184.8	0.746	0.699	0.938	0.972	0.944	1.677	76.4
29.00	21470.	16010.	174.5	79.14	1427.1	197.4	0.746	0.701	0.940	0.969	0.943	1.676	79.0
30.00	23648.	17635.	185.8	84.29	1520.4	210.3	0.746	0.702	0.941	0.970	0.944	1.678	81.7
31.00	26081.	19449.	197.4	89.54	1622.7	224.4	0.746	0.699	0.938	0.971	0.944	1.680	84.4
32.00	28718.	21415.	209.4	94.98	1729.9	239.2	0.746	0.697	0.935	0.973	0.945	1.683	87.2
33.00	31728.	23659.	223.1	101.19	1850.1	255.9	0.746	0.695	0.932	0.976	0.946	1.684	90.1
34.00	35210.	26256.	239.4	108.58	1987.0	274.8	0.746	0.693	0.929	0.977	0.946	1.681	93.1
35.00	39192.	29226.	259.0	117.47	2139.8	295.9	0.746	0.694	0.930	0.977	0.946	1.675	96.2
36.00	43646.	32547.	282.8	128.28	2304.6	318.7	0.745	0.699	0.938	0.976	0.947	1.665	99.5
37.00	49149.	36651.	312.3	141.66	2507.2	346.8	0.745	0.703	0.944	0.974	0.947	1.649	103.0
38.00	55738.	41564.	348.0	157.86	2742.3	379.3	0.743	0.707	0.952	0.971	0.947	1.629	106.7
39.00	63661.	47472.	388.9	176.41	3017.3	417.3	0.741	0.709	0.957	0.970	0.947	1.608	110.8
40.00	73189.	54577.	435.1	197.38	3335.3	461.3	0.739	0.709	0.959	0.971	0.948	1.587	115.3
41.00	84670.	63139.	485.5	220.24	3704.5	512.3	0.736	0.704	0.956	0.975	0.949	1.570	120.0
42.00	98543.	73484.	539.2	244.56	4130.3	571.2	0.734	0.695	0.947	0.986	0.952	1.557	125.3

Table A21. HSS HCRSP Powering Prediction, Exp87, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 2.5 degrees to Outboard - continued

HSS-HCRSP Exp87 FA+Flap+BK DES 2.5degOutbd Alignment

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1999.	1491.	47.4	21.52	247.6	34.2	0.823	0.933	1.134	0.854	0.920	1.799	42.4
16.00	2332.	1739.	52.0	23.60	272.8	37.7	0.822	0.936	1.140	0.855	0.920	1.814	44.9
17.00	2726.	2033.	56.4	25.58	301.9	41.7	0.821	0.927	1.130	0.859	0.918	1.834	47.4
18.00	3183.	2374.	60.7	27.55	334.1	46.2	0.820	0.914	1.114	0.867	0.918	1.857	50.0
19.00	3695.	2756.	65.0	29.49	368.2	50.9	0.820	0.899	1.096	0.876	0.918	1.881	52.7
20.00	4262.	3178.	69.5	31.53	404.4	55.9	0.820	0.885	1.079	0.884	0.918	1.902	55.4
21.00	4881.	3640.	74.3	33.72	442.3	61.2	0.821	0.873	1.063	0.889	0.916	1.919	58.0
22.00	5552.	4140.	79.7	36.13	481.4	66.6	0.821	0.865	1.054	0.893	0.916	1.932	60.6
23.00	6285.	4687.	85.5	38.78	521.5	72.1	0.821	0.862	1.050	0.898	0.919	1.943	63.3
24.00	7096.	5291.	91.9	41.66	565.3	78.2	0.822	0.857	1.044	0.899	0.917	1.950	65.9
25.00	7935.	5917.	98.6	44.75	607.4	84.0	0.822	0.859	1.046	0.901	0.920	1.955	68.6
26.00	8831.	6585.	106.0	48.08	650.9	90.0	0.822	0.863	1.050	0.901	0.921	1.957	71.3
27.00	9784.	7296.	113.6	51.51	696.0	96.3	0.822	0.865	1.053	0.899	0.920	1.959	73.8
28.00	10820.	8069.	121.2	54.99	743.9	102.9	0.822	0.865	1.052	0.898	0.919	1.960	76.4
29.00	11938.	8902.	129.1	58.58	793.5	109.7	0.822	0.865	1.052	0.898	0.919	1.963	79.0
30.00	13168.	9819.	137.1	62.20	846.9	117.1	0.822	0.862	1.049	0.899	0.918	1.967	81.7
31.00	14534.	10838.	145.4	65.97	904.7	125.1	0.822	0.858	1.043	0.901	0.918	1.971	84.4
32.00	16064.	11979.	154.3	69.98	968.2	133.9	0.822	0.852	1.036	0.903	0.917	1.975	87.1
33.00	17797.	13271.	164.2	74.47	1038.2	143.6	0.822	0.846	1.029	0.905	0.917	1.977	90.0
34.00	19780.	14750.	175.8	79.76	1116.4	154.4	0.822	0.842	1.024	0.908	0.917	1.975	93.1
35.00	22035.	16432.	189.7	86.07	1203.7	166.5	0.822	0.840	1.021	0.908	0.917	1.968	96.1
36.00	24556.	18312.	206.5	93.69	1297.5	179.4	0.822	0.843	1.026	0.907	0.918	1.957	99.4
37.00	27621.	20597.	226.4	102.71	1409.5	194.9	0.821	0.844	1.028	0.907	0.919	1.942	102.9
38.00	31224.	23284.	249.9	113.36	1536.9	212.6	0.821	0.847	1.032	0.907	0.922	1.925	106.7
39.00	35460.	26443.	276.7	125.53	1680.6	232.4	0.821	0.850	1.036	0.910	0.926	1.907	110.8
40.00	40489.	30193.	305.6	138.63	1846.0	255.3	0.820	0.848	1.034	0.915	0.931	1.892	115.2
41.00	46432.	34624.	335.9	152.35	2032.4	281.1	0.820	0.842	1.027	0.926	0.939	1.884	120.0
42.00	53504.	39898.	367.1	166.51	2243.4	310.3	0.820	0.833	1.016	0.942	0.951	1.882	125.3

Table A22. HSS HCRSP Powering Prediction, Exp88, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 5 degrees to Outboard

HSS-HCRSP Exp88 FA+Flap+BK DES 5degOutbd Alignment

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED (KNOTS)	SHIP SPEED (M/SEC)	EFFECTIVE POWER (HP)	EFFECTIVE POWER (KW)	DELIVERED POWER (HP)	DELIVERED POWER (KW)	ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
15.0	7.72	7390.	5511.	11364.	8474.	0.650	0.783	0.834	0.794	2.255	1.413	0.842
16.0	8.23	8807.	6567.	13336.	9945.	0.660	0.782	0.842	0.798	2.214	1.402	0.812
17.0	8.75	10401.	7756.	15681.	11693.	0.663	0.783	0.837	0.808	2.180	1.392	0.788
18.0	9.26	12186.	9087.	18421.	13737.	0.662	0.783	0.824	0.817	2.152	1.383	0.769
19.0	9.77	14116.	10526.	21493.	16027.	0.657	0.783	0.809	0.827	2.119	1.374	0.745
20.0	10.29	16264.	12128.	24901.	18569.	0.653	0.783	0.796	0.835	2.093	1.366	0.728
21.0	10.80	18625.	13889.	28619.	21341.	0.651	0.784	0.785	0.842	2.071	1.358	0.713
22.0	11.32	21232.	15833.	32611.	24318.	0.651	0.784	0.779	0.847	2.053	1.350	0.703
23.0	11.83	24110.	17979.	36852.	27481.	0.654	0.784	0.777	0.850	2.041	1.343	0.697
24.0	12.35	27276.	20340.	41430.	30895.	0.658	0.784	0.777	0.853	2.032	1.337	0.695
25.0	12.86	30726.	22912.	46270.	34504.	0.664	0.784	0.780	0.853	2.025	1.331	0.694
26.0	13.38	34441.	25683.	51405.	38333.	0.670	0.784	0.784	0.852	2.018	1.325	0.693
27.0	13.89	38391.	28628.	56868.	42407.	0.675	0.784	0.788	0.851	2.008	1.319	0.690
28.0	14.40	42545.	31726.	62851.	46868.	0.677	0.784	0.791	0.849	1.996	1.313	0.682
29.0	14.92	46891.	34967.	69333.	51702.	0.676	0.784	0.792	0.846	1.980	1.308	0.672
30.0	15.43	51459.	38373.	76430.	56994.	0.673	0.784	0.790	0.844	1.963	1.303	0.660
31.0	15.95	56335.	42009.	84218.	62801.	0.669	0.784	0.788	0.841	1.947	1.298	0.649
32.0	16.46	61687.	46000.	93132.	69449.	0.662	0.784	0.784	0.840	1.939	1.293	0.645
33.0	16.98	67770.	50536.	103206.	76961.	0.657	0.784	0.779	0.839	1.942	1.289	0.653
34.0	17.49	74926.	55872.	114636.	85484.	0.654	0.784	0.776	0.839	1.963	1.284	0.679
35.0	18.01	83558.	62309.	127964.	95423.	0.653	0.784	0.774	0.840	2.007	1.280	0.727
36.0	18.52	94100.	70170.	143419.	106947.	0.656	0.783	0.775	0.842	2.077	1.276	0.801
37.0	19.03	106949.	79752.	161629.	120527.	0.662	0.783	0.777	0.846	2.174	1.272	0.902
38.0	19.55	122400.	91274.	182834.	136339.	0.669	0.782	0.780	0.850	2.297	1.268	1.029
39.0	20.06	140564.	104819.	207776.	154938.	0.677	0.780	0.781	0.856	2.440	1.265	1.175
40.0	20.58	161309.	120288.	237286.	176944.	0.680	0.779	0.779	0.863	2.595	1.261	1.334
41.0	21.09	184243.	137390.	272034.	202856.	0.677	0.778	0.773	0.870	2.753	1.258	1.495
42.0	21.61	209306.	156079.	313187.	233544.	0.668	0.777	0.761	0.879	2.909	1.254	1.655

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A22. HSS HCRSP Powering Prediction, Exp88, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 5 degrees to Outboard - continued

HSS-HCRSP Exp88 FA+Flap+BK DES 5degOutbd Alignment

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3725.	2778.	55.1	25.01	450.1	62.3	0.745	0.693	0.930	1.017	0.982	1.654	43.5
16.00	4412.	3290.	62.2	28.21	503.6	69.6	0.745	0.697	0.936	1.008	0.976	1.650	46.0
17.00	5200.	3878.	69.0	31.31	561.4	77.6	0.745	0.696	0.934	1.005	0.972	1.654	48.7
18.00	6105.	4553.	76.0	34.46	625.1	86.4	0.745	0.690	0.926	1.004	0.967	1.660	51.3
19.00	7101.	5295.	82.8	37.56	691.2	95.6	0.745	0.683	0.917	1.005	0.964	1.667	54.0
20.00	8198.	6113.	90.0	40.83	760.4	105.2	0.746	0.678	0.909	1.006	0.962	1.674	56.6
21.00	9388.	7000.	97.5	44.23	831.8	115.0	0.746	0.674	0.903	1.006	0.960	1.679	59.3
22.00	10659.	7948.	105.7	47.93	903.6	125.0	0.746	0.673	0.903	1.006	0.960	1.683	61.9
23.00	12007.	8954.	114.5	51.93	976.6	135.1	0.746	0.676	0.906	1.004	0.960	1.685	64.6
24.00	13476.	10049.	123.9	56.22	1053.6	145.7	0.746	0.678	0.909	1.001	0.959	1.684	67.2
25.00	15032.	11210.	134.2	60.88	1130.9	156.4	0.746	0.683	0.917	0.998	0.959	1.683	69.8
26.00	16687.	12443.	145.0	65.79	1210.6	167.4	0.746	0.689	0.924	0.993	0.959	1.681	72.4
27.00	18457.	13764.	156.3	70.91	1292.6	178.8	0.746	0.695	0.932	0.990	0.959	1.679	75.0
28.00	20415.	15224.	167.7	76.08	1381.9	191.1	0.746	0.697	0.934	0.987	0.957	1.678	77.6
29.00	22544.	16811.	179.7	81.52	1475.1	204.0	0.746	0.699	0.937	0.985	0.957	1.677	80.3
30.00	24883.	18556.	191.7	86.95	1575.7	217.9	0.746	0.698	0.936	0.984	0.956	1.677	82.9
31.00	27454.	20472.	204.5	92.75	1683.4	232.8	0.746	0.697	0.935	0.984	0.955	1.677	85.7
32.00	30418.	22682.	218.1	98.94	1805.8	249.7	0.746	0.693	0.930	0.984	0.953	1.677	88.5
33.00	33750.	25167.	233.3	105.84	1939.5	268.2	0.746	0.690	0.925	0.985	0.951	1.676	91.4
34.00	37538.	27992.	251.4	114.05	2088.8	288.9	0.746	0.688	0.923	0.985	0.949	1.671	94.4
35.00	41947.	31280.	273.2	123.91	2258.1	312.3	0.745	0.688	0.923	0.984	0.947	1.663	97.6
36.00	47050.	35085.	299.1	135.66	2447.9	338.5	0.745	0.690	0.927	0.983	0.946	1.651	100.9
37.00	53050.	39559.	330.3	149.81	2666.3	368.7	0.744	0.693	0.931	0.980	0.944	1.635	104.5
38.00	60000.	44742.	367.0	166.47	2909.8	402.4	0.742	0.697	0.939	0.977	0.944	1.615	108.3
39.00	68103.	50784.	408.9	185.50	3185.0	440.5	0.740	0.700	0.947	0.974	0.944	1.594	112.3
40.00	77702.	57942.	454.4	206.12	3499.7	484.0	0.737	0.700	0.949	0.975	0.944	1.575	116.6
41.00	88920.	66308.	502.9	228.10	3854.2	533.0	0.735	0.696	0.947	0.978	0.945	1.559	121.2
42.00	******	76211.	552.4	250.55	4256.5	588.7	0.733	0.688	0.938	0.988	0.947	1.550	126.1

Table A22. HSS HCRSP Powering Prediction, Exp88, Fully Appended, DES Displacement, F:A RPM = 1:1, Pods Alignment Angle of LE 5 degrees to Outboard - continued

HSS-HCRSP Exp88 FA+Flap+BK DES 5degOutbd Alignment

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1957.	1459.	46.0	20.85	236.6	32.7	0.820	0.975	1.189	0.902	0.983	1.854	43.5
16.00	2256.	1682.	50.2	22.75	257.5	35.6	0.820	0.987	1.204	0.904	0.987	1.873	46.0
17.00	2640.	1969.	54.4	24.68	285.1	39.4	0.820	0.978	1.192	0.909	0.985	1.893	48.6
18.00	3106.	2316.	59.0	26.76	318.1	44.0	0.821	0.958	1.168	0.913	0.980	1.910	51.3
19.00	3646.	2719.	63.6	28.84	355.0	49.1	0.821	0.934	1.138	0.919	0.973	1.928	53.9
20.00	4253.	3172.	68.7	31.14	394.6	54.6	0.821	0.914	1.113	0.922	0.967	1.941	56.6
21.00	4922.	3670.	74.1	33.61	436.1	60.3	0.822	0.897	1.092	0.925	0.961	1.951	59.3
22.00	5647.	4211.	80.0	36.28	479.0	66.2	0.822	0.885	1.077	0.925	0.956	1.958	61.9
23.00	6419.	4787.	86.3	39.17	522.3	72.2	0.822	0.878	1.068	0.925	0.952	1.962	64.6
24.00	7239.	5398.	93.2	42.29	566.0	78.3	0.822	0.875	1.065	0.923	0.949	1.964	67.2
25.00	8103.	6042.	100.5	45.60	610.0	84.4	0.822	0.876	1.066	0.921	0.947	1.964	69.8
26.00	9016.	6723.	108.2	49.10	654.4	90.5	0.822	0.879	1.069	0.918	0.945	1.964	72.4
27.00	9977.	7440.	116.0	52.60	699.0	96.7	0.822	0.882	1.073	0.916	0.945	1.965	75.0
28.00	11011.	8211.	123.9	56.21	745.2	103.1	0.822	0.885	1.077	0.915	0.945	1.967	77.6
29.00	12123.	9040.	131.6	59.69	793.7	109.8	0.822	0.884	1.076	0.915	0.944	1.971	80.2
30.00	13331.	9941.	139.5	63.26	844.9	116.8	0.822	0.882	1.073	0.916	0.944	1.975	82.9
31.00	14655.	10928.	147.5	66.89	898.8	124.3	0.822	0.880	1.070	0.919	0.945	1.981	85.6
32.00	16148.	12042.	156.0	70.74	959.0	132.6	0.822	0.874	1.063	0.922	0.946	1.986	88.4
33.00	17853.	13313.	165.5	75.06	1026.7	142.0	0.822	0.868	1.055	0.924	0.946	1.990	91.3
34.00	19780.	14750.	176.7	80.15	1101.0	152.3	0.822	0.864	1.051	0.927	0.947	1.989	94.4
35.00	22035.	16432.	190.1	86.24	1186.5	164.1	0.822	0.861	1.047	0.929	0.947	1.985	97.5
36.00	24659.	18388.	206.7	93.78	1283.6	177.5	0.822	0.861	1.047	0.929	0.948	1.975	100.9
37.00	27765.	20704.	226.6	102.80	1396.3	193.1	0.822	0.861	1.048	0.929	0.949	1.960	104.4
38.00	31417.	23428.	250.2	113.47	1524.5	210.8	0.821	0.863	1.050	0.929	0.951	1.943	108.2
39.00	35785.	26685.	277.3	125.77	1674.2	231.5	0.821	0.862	1.050	0.929	0.952	1.923	112.3
40.00	40941.	30530.	307.0	139.27	1845.0	255.2	0.821	0.858	1.046	0.932	0.953	1.905	116.5
41.00	47097.	35120.	338.7	153.62	2041.2	282.3	0.820	0.849	1.035	0.939	0.956	1.891	121.2
42.00	54393.	40561.	371.4	168.49	2267.1	313.5	0.820	0.834	1.017	0.948	0.957	1.882	126.0

Table A23. HSS HCRSP Powering Prediction, Exp95, Stern Flap Removed, DES Displacement, F:A RPM = 1:1

HSS-HCRSP Exp95 FA+BK DES NoFlap

LENGTH (LWL)	978.2 FT (298.2 M)
DISPLACEMENT	36494.2 TONS (37078.1 TONNES)
WETTED SURFACE	111619.4 SQ FT (10369.8 SQ M)
INBOARD PROP DIA	21.50 FT (6.55 M)
OUTBOARD PROP DIA	17.00 FT (5.18 M)
CORRELATION ALLOWANCE	0.00000
ITTC FRICTION USED	

TOTAL (ALL FOUR SHAFTS COMBINED)

SHIP SPEED		EFFECTIVE POWER		DELIVERED POWER		ETAD	ETAO+	ETAB+	1-t	CTS	CFS	CR
(KNOTS)	(M/SEC)	(HP)	(KW)	(HP)	(KW)							
15.0	7.72	7272.	5423.	10340.	7711.	0.703	0.787	0.880	0.773	2.219	1.413	0.806
16.0	8.23	8699.	6487.	12271.	9151.	0.709	0.788	0.890	0.761	2.187	1.402	0.785
17.0	8.75	10281.	7667.	14613.	10897.	0.704	0.786	0.878	0.763	2.155	1.392	0.763
18.0	9.26	12050.	8986.	17246.	12860.	0.699	0.785	0.863	0.771	2.128	1.383	0.745
19.0	9.77	14033.	10464.	20379.	15197.	0.689	0.784	0.841	0.783	2.107	1.374	0.733
20.0	10.29	16249.	12117.	23810.	17755.	0.682	0.783	0.826	0.792	2.092	1.366	0.726
21.0	10.80	18686.	13934.	27553.	20547.	0.678	0.783	0.814	0.800	2.078	1.358	0.720
22.0	11.32	21388.	15949.	31562.	23536.	0.678	0.783	0.806	0.808	2.068	1.350	0.718
23.0	11.83	24405.	18199.	35816.	26708.	0.681	0.783	0.805	0.813	2.065	1.343	0.722
24.0	12.35	27706.	20660.	40359.	30096.	0.686	0.783	0.806	0.817	2.064	1.337	0.727
25.0	12.86	31281.	23326.	45127.	33651.	0.693	0.783	0.809	0.821	2.062	1.331	0.731
26.0	13.38	35101.	26175.	50154.	37400.	0.700	0.783	0.813	0.823	2.056	1.325	0.732
27.0	13.89	39161.	29202.	55531.	41409.	0.705	0.783	0.817	0.824	2.049	1.319	0.730
28.0	14.40	43579.	32497.	61331.	45735.	0.711	0.783	0.821	0.826	2.044	1.313	0.731
29.0	14.92	48174.	35923.	67647.	50444.	0.712	0.783	0.822	0.827	2.034	1.308	0.726
30.0	15.43	53093.	39591.	74447.	55515.	0.713	0.783	0.821	0.829	2.025	1.303	0.722
31.0	15.95	58382.	43535.	82114.	61232.	0.711	0.783	0.818	0.831	2.018	1.298	0.720
32.0	16.46	64385.	48012.	90800.	67709.	0.709	0.783	0.814	0.834	2.023	1.293	0.730
33.0	16.98	71082.	53006.	100554.	74983.	0.707	0.783	0.809	0.838	2.037	1.289	0.748
34.0	17.49	78797.	58759.	111893.	83438.	0.704	0.783	0.803	0.842	2.064	1.284	0.780
35.0	18.01	87903.	65549.	125062.	93259.	0.703	0.783	0.798	0.846	2.111	1.280	0.831
36.0	18.52	98551.	73489.	140581.	104831.	0.701	0.783	0.793	0.850	2.175	1.276	0.899
37.0	19.03	111620.	83235.	158792.	118411.	0.703	0.782	0.791	0.853	2.269	1.272	0.997
38.0	19.55	127641.	95182.	180336.	134477.	0.708	0.781	0.793	0.856	2.395	1.268	1.127
39.0	20.06	146873.	109523.	205786.	153455.	0.714	0.780	0.796	0.856	2.550	1.265	1.285
40.0	20.58	168680.	125785.	236237.	176162.	0.714	0.778	0.795	0.858	2.714	1.261	1.453
41.0	21.09	193062.	143966.	272623.	203295.	0.708	0.777	0.792	0.858	2.885	1.258	1.627
42.0	21.61	219163.	163430.	315926.	235586.	0.694	0.777	0.787	0.855	3.046	1.254	1.792

+ETAO and ETAB (TOTAL) = AVERAGE OF INBOARD AND OUTBOARD VALUES

Table A23. HSS HCRSP Powering Prediction, Exp95, Stern Flap Removed, DES Displacement, F:A RPM = 1:1 - continued

HSS-HCRSP Exp95 FA+BK DES NoFlap

INBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	3246.	2421.	50.3	22.82	399.3	55.2	0.746	0.725	0.972	1.016	1.005	1.682	42.7
16.00	3856.	2875.	57.9	26.26	447.9	61.9	0.746	0.738	0.990	1.001	0.997	1.669	45.2
17.00	4598.	3429.	65.4	29.68	505.4	69.9	0.745	0.737	0.989	0.992	0.987	1.663	47.8
18.00	5418.	4040.	73.0	33.12	564.5	78.1	0.745	0.736	0.987	0.988	0.982	1.662	50.4
19.00	6425.	4791.	80.5	36.54	636.0	88.0	0.745	0.721	0.967	0.986	0.972	1.664	53.1
20.00	7523.	5610.	89.2	40.46	708.7	98.0	0.745	0.716	0.961	0.984	0.966	1.663	55.8
21.00	8715.	6499.	98.0	44.43	783.8	108.4	0.745	0.711	0.954	0.981	0.960	1.662	58.4
22.00	9994.	7453.	107.0	48.55	859.5	118.9	0.745	0.708	0.950	0.980	0.957	1.663	61.1
23.00	11341.	8457.	116.8	52.99	934.0	129.2	0.745	0.711	0.954	0.978	0.958	1.662	63.8
24.00	12780.	9530.	126.7	57.49	1010.4	139.7	0.745	0.713	0.957	0.977	0.957	1.662	66.4
25.00	14271.	10642.	137.0	62.15	1085.0	150.1	0.745	0.718	0.964	0.975	0.959	1.662	69.1
26.00	15840.	11812.	147.4	66.87	1160.1	160.4	0.745	0.723	0.970	0.974	0.961	1.663	71.7
27.00	17514.	13060.	158.0	71.65	1236.6	171.0	0.745	0.728	0.976	0.974	0.964	1.665	74.4
28.00	19317.	14405.	169.1	76.69	1316.8	182.1	0.745	0.732	0.982	0.973	0.966	1.667	77.0
29.00	21278.	15867.	180.0	81.63	1402.1	193.9	0.745	0.733	0.983	0.974	0.967	1.669	79.7
30.00	23368.	17426.	191.5	86.85	1489.3	206.0	0.746	0.735	0.986	0.975	0.969	1.672	82.4
31.00	25742.	19196.	203.2	92.18	1586.8	219.4	0.746	0.734	0.984	0.977	0.971	1.675	85.2
32.00	28439.	21207.	216.8	98.35	1696.2	234.6	0.746	0.733	0.983	0.979	0.972	1.676	88.1
33.00	31452.	23454.	232.1	105.29	1815.9	251.1	0.746	0.732	0.982	0.980	0.972	1.674	91.0
34.00	34990.	26092.	249.7	113.28	1955.0	270.4	0.746	0.730	0.979	0.980	0.971	1.670	94.0
35.00	39103.	29159.	270.6	122.76	2113.7	292.3	0.745	0.729	0.977	0.980	0.970	1.663	97.2
36.00	43996.	32808.	295.4	133.99	2298.5	317.9	0.745	0.727	0.976	0.980	0.969	1.653	100.5
37.00	49742.	37092.	325.9	147.85	2509.0	347.0	0.744	0.728	0.978	0.978	0.968	1.638	104.1
38.00	56578.	42191.	363.4	164.84	2753.8	380.9	0.742	0.730	0.983	0.974	0.966	1.617	107.9
39.00	64645.	48206.	408.5	185.31	3032.5	419.4	0.739	0.733	0.992	0.969	0.965	1.591	112.0
40.00	74374.	55461.	458.7	208.05	3356.1	464.1	0.736	0.732	0.995	0.968	0.965	1.566	116.4
41.00	86035.	64156.	512.9	232.63	3729.1	515.7	0.733	0.727	0.993	0.970	0.965	1.546	121.2
42.00	99983.	74557.	569.9	258.48	4156.2	574.8	0.730	0.718	0.984	0.978	0.967	1.531	126.3

Table A23. HSS HCRSP Powering Prediction, Exp95, Stern Flap Removed, DES Displacement, F:A RPM = 1:1 - continued

HSS-HCRSP Exp95 FA+BK DES NoFlap

OUTBOARD (PER SHAFT)

SPEED (KNOTS)	DELIVERED POWER (HP)	(KW)	THRUST (X1000) (LBS)	(KG)	TORQUE (X1000) (FT-LB)	(KG-M)	ETAO	ETAB	ETAR	1-WT	1-WQ	JT	PROPELLER RPM
15.00	1924.	1435.	51.8	23.51	236.7	32.7	0.829	1.036	1.249	0.835	0.950	1.748	42.7
16.00	2280.	1700.	58.4	26.51	264.9	36.6	0.830	1.042	1.256	0.828	0.945	1.745	45.2
17.00	2708.	2020.	63.7	28.91	297.7	41.2	0.827	1.020	1.234	0.831	0.937	1.761	47.8
18.00	3205.	2390.	68.5	31.08	334.0	46.2	0.824	0.990	1.202	0.839	0.930	1.784	50.4
19.00	3764.	2807.	73.1	33.16	372.7	51.5	0.822	0.961	1.169	0.848	0.925	1.810	53.1
20.00	4382.	3268.	78.0	35.36	413.1	57.1	0.821	0.936	1.140	0.857	0.920	1.833	55.7
21.00	5061.	3774.	83.2	37.75	455.3	63.0	0.820	0.916	1.117	0.865	0.917	1.852	58.4
22.00	5787.	4315.	89.1	40.41	497.8	68.8	0.820	0.904	1.103	0.870	0.915	1.867	61.1
23.00	6568.	4897.	95.8	43.47	541.1	74.8	0.820	0.899	1.096	0.873	0.915	1.876	63.7
24.00	7400.	5518.	103.3	46.88	585.4	81.0	0.820	0.898	1.095	0.873	0.915	1.880	66.4
25.00	8293.	6184.	111.4	50.53	630.7	87.2	0.820	0.900	1.097	0.873	0.915	1.883	69.1
26.00	9237.	6888.	119.9	54.40	676.7	93.6	0.820	0.903	1.101	0.872	0.915	1.883	71.7
27.00	10252.	7645.	128.7	58.39	724.2	100.2	0.820	0.906	1.105	0.871	0.916	1.885	74.3
28.00	11349.	8463.	138.1	62.65	774.2	107.1	0.820	0.910	1.109	0.870	0.916	1.884	77.0
29.00	12545.	9355.	147.3	66.80	826.7	114.3	0.820	0.910	1.110	0.871	0.917	1.888	79.7
30.00	13855.	10332.	156.5	71.01	883.0	122.1	0.820	0.908	1.106	0.873	0.917	1.892	82.4
31.00	15315.	11421.	165.9	75.24	944.6	130.6	0.820	0.902	1.099	0.875	0.917	1.897	85.2
32.00	16961.	12648.	176.1	79.86	1012.4	140.0	0.820	0.895	1.090	0.878	0.916	1.901	88.0
33.00	18825.	14038.	186.9	84.77	1087.6	150.4	0.821	0.886	1.079	0.881	0.915	1.905	90.9
34.00	20957.	15627.	199.0	90.24	1171.4	162.0	0.821	0.877	1.068	0.885	0.914	1.907	94.0
35.00	23428.	17470.	213.1	96.68	1266.8	175.2	0.821	0.868	1.057	0.888	0.913	1.905	97.1
36.00	26294.	19608.	229.4	104.08	1373.9	190.0	0.820	0.860	1.048	0.892	0.913	1.902	100.5
37.00	29655.	22113.	250.0	113.41	1497.0	207.0	0.820	0.854	1.042	0.893	0.912	1.890	104.0
38.00	33590.	25048.	276.1	125.25	1635.4	226.2	0.820	0.855	1.043	0.892	0.913	1.872	107.9
39.00	38248.	28522.	308.0	139.72	1794.6	248.2	0.820	0.858	1.046	0.890	0.914	1.848	111.9
40.00	43745.	32621.	342.5	155.37	1975.1	273.2	0.821	0.858	1.045	0.892	0.917	1.827	116.3
41.00	50277.	37491.	381.7	173.14	2180.1	301.5	0.822	0.857	1.043	0.897	0.922	1.809	121.1
42.00	57980.	43235.	425.1	192.83	2410.4	333.4	0.823	0.855	1.039	0.905	0.929	1.792	126.3

Table A24a. HSS simulated Twin-Screw Powering Prediction, Exp97, DES

SHIP LENGTH 978.2 FEET (298.2 METERS)
SHIP DISPLACEMENT 36494. TONS (37080. METRIC TONS)
SHIP WETTED SURFACE 111619. SQFT (10369. SQ METERS)
CORRELATION ALLOWANCE .00000 ITTC FRICTION USED

SHIP SPEED		RESIDUARY RES.COEF.	EFFECTIVE POWER- PE		DELIVERED POWER- PD		PROPELLER REV. PER
(KTS)	(M/S)	(CR*1000)	(HP)	(kW)	(HP)	(kW)	MINUTE
15.0	7.72	0.583	6542.0	4878.4	10064.6	7505.2	47.1
16.0	8.23	0.547	7753.0	5781.4	11854.7	8840.1	49.8
17.0	8.75	0.515	9097.0	6783.6	13867.4	10340.9	52.6
18.0	9.26	0.490	10605.0	7908.1	16467.4	12279.7	55.5
19.0	9.77	0.473	12301.0	9172.9	19556.4	14583.2	58.5
20.0	10.29	0.463	14203.0	10591.2	23131.9	17249.5	61.5
21.0	10.80	0.459	16339.0	12184.0	27141.2	20239.2	64.5
22.0	11.32	0.460	18723.0	13961.7	31467.2	23465.1	67.6
23.0	11.83	0.462	21337.0	15911.0	36164.4	26967.8	70.6
24.0	12.35	0.466	24196.0	18043.0	41079.8	30633.2	73.6
25.0	12.86	0.467	27271.0	20336.0	46300.5	34526.3	76.5
26.0	13.38	0.467	30577.0	22801.3	51737.7	38580.8	79.5
27.0	13.89	0.465	34100.0	25428.4	57504.2	42880.9	82.4
28.0	14.40	0.463	37856.0	28229.2	63623.5	47444.1	85.3
29.0	14.92	0.461	41892.0	31238.9	70053.5	52238.9	88.2
30.0	15.43	0.462	46274.0	34506.5	77123.3	57510.9	91.1
31.0	15.95	0.468	51088.0	38096.3	84863.8	63282.9	94.2
32.0	16.46	0.480	56418.0	42070.9	93717.6	69885.2	97.3
33.0	16.98	0.499	62395.0	46527.9	103646.2	77288.9	100.5
34.0	17.49	0.541	69663.0	51947.7	115336.1	86006.1	103.9
35.0	18.01	0.598	78192.0	58307.8	129029.7	96217.4	107.6
36.0	18.52	0.672	88273.0	65825.2	145425.0	108443.4	111.6
37.0	19.03	0.765	100202.0	74720.6	165077.4	123098.2	115.9
38.0	19.55	0.876	114262.0	85205.2	188862.8	140835.0	120.6
39.0	20.06	1.005	130760.0	97507.7	217933.3	162512.9	125.8

SHIP SPEED	EFFICIENCIES (ETA)					THRUST DEDUCTION AND WAKE FACTORS			ADVANCE COEF.
(KTS)	ETAD	ETAO	ETAH	ETAR	ETAB	1-THDF	1-WFTT	1-WFTQ	ADVC
15.0	0.650	0.735	0.930	0.950	0.700	0.990	1.065	1.030	1.595
16.0	0.655	0.735	0.935	0.950	0.700	0.985	1.055	1.025	1.595
17.0	0.655	0.735	0.930	0.960	0.705	0.970	1.045	1.020	1.595
18.0	0.645	0.735	0.920	0.950	0.700	0.960	1.040	1.010	1.590
19.0	0.630	0.735	0.910	0.940	0.690	0.945	1.040	1.000	1.590
20.0	0.615	0.735	0.900	0.925	0.680	0.935	1.035	0.985	1.585
21.0	0.600	0.735	0.895	0.915	0.675	0.925	1.035	0.975	1.585
22.0	0.595	0.735	0.890	0.910	0.670	0.915	1.030	0.970	1.580
23.0	0.590	0.735	0.885	0.905	0.665	0.910	1.030	0.960	1.580
24.0	0.590	0.735	0.885	0.905	0.665	0.910	1.025	0.960	1.575
25.0	0.590	0.735	0.885	0.905	0.665	0.905	1.025	0.955	1.575
26.0	0.590	0.735	0.885	0.905	0.665	0.905	1.020	0.955	1.575
27.0	0.595	0.735	0.890	0.905	0.665	0.905	1.020	0.955	1.575
28.0	0.595	0.735	0.890	0.905	0.670	0.910	1.020	0.955	1.575
29.0	0.600	0.735	0.895	0.910	0.670	0.910	1.020	0.960	1.580
30.0	0.600	0.735	0.895	0.910	0.670	0.910	1.020	0.960	1.580
31.0	0.600	0.735	0.895	0.910	0.670	0.915	1.020	0.960	1.580
32.0	0.600	0.735	0.900	0.910	0.670	0.920	1.020	0.960	1.580
33.0	0.600	0.735	0.900	0.905	0.670	0.920	1.020	0.960	1.580
34.0	0.605	0.735	0.905	0.910	0.670	0.925	1.020	0.960	1.575
35.0	0.605	0.735	0.905	0.910	0.670	0.925	1.020	0.955	1.565
36.0	0.605	0.735	0.910	0.910	0.670	0.930	1.020	0.960	1.555
37.0	0.605	0.730	0.910	0.915	0.670	0.930	1.020	0.960	1.535
38.0	0.605	0.725	0.905	0.915	0.665	0.930	1.025	0.960	1.520
39.0	0.600	0.725	0.905	0.920	0.665	0.930	1.030	0.965	1.500

Table A24b. HSS simulated Twin-Screw Powering Estimate, with rudders and stern flap, using high speed propeller 5506 characteristics

HSS 2Screw BK+Flap+Rudders DES, OWC HiVs Prop5506

SHIP LENGTH 978.2 FEET (298.2 METERS)
SHIP DISPLACEMENT 36494. TONS (37080. METRIC TONS)
SHIP WETTED SURFACE 111619 SQFT (10369. SQ METERS)
CORRELATION ALLOWANCE .00000 ITTC FRICTION USED

SHIP SPEED		RESIDUARY	EFFECTIVE		DELIVERED		PROPELLER
		RES.COEF.	POWER- PE		POWER- PD		REV. PER
(KTS)	(M/S)	(CR*1000)	(HP)	(kW)	(HP)	(kW)	MINUTE
15.0	7.72	0.653	6772.0	5049.9	10574.9	7885.7	64.8
16.0	8.23	0.611	8007.0	5970.8	12664.6	9444.0	68.6
17.0	8.75	0.585	9431.0	7032.7	15140.6	11290.3	72.6
18.0	9.26	0.564	11026.0	8222.1	17984.1	13410.8	76.8
19.0	9.77	0.540	12746.0	9504.7	21082.8	15721.4	80.9
20.0	10.29	0.522	14667.0	10937.2	24515.9	18281.5	85.1
21.0	10.80	0.514	16830.0	12550.1	28285.0	21092.1	89.4
22.0	11.32	0.510	19234.0	14342.8	32514.7	24246.2	93.6
23.0	11.83	0.505	21840.0	16286.1	36964.2	27564.2	97.7
24.0	12.35	0.503	24702.0	18420.3	41710.4	31103.4	101.8
25.0	12.86	0.502	27799.0	20729.7	46902.6	34975.3	106.0
26.0	13.38	0.501	31154.0	23231.5	52498.7	39148.3	110.0
27.0	13.89	0.498	34726.0	25895.2	58348.3	43510.3	114.0
28.0	14.40	0.487	38388.0	28625.9	64415.4	48034.5	118.0
29.0	14.92	0.481	42362.0	31589.3	70967.4	52920.4	121.8
30.0	15.43	0.474	46601.0	34750.4	77961.2	58135.7	125.9
31.0	15.95	0.473	51248.0	38215.6	85459.0	63726.8	129.6
32.0	16.46	0.473	56218.0	41921.8	93517.8	69736.2	133.6
33.0	16.98	0.486	61928.0	46179.7	102410.8	76367.7	137.5
34.0	17.49	0.524	69044.0	51486.1	113604.2	84714.7	141.8
35.0	18.01	0.583	77564.0	57839.5	126789.1	94546.6	146.1
36.0	18.52	0.667	88052.0	65660.4	142399.2	106187.1	150.7
37.0	19.03	0.767	100300.0	74793.7	160943.0	120015.2	155.6
38.0	19.55	0.877	114326.0	85252.9	182105.2	135795.8	160.7
39.0	20.06	0.997	130256.0	97131.9	205829.3	153486.9	166.0

SHIP	EFFICIENCIES (ETA)					THRUST DEDUCTION AND WAKE FACTORS			ADVANCE
SPEED									COEF.
(KTS)	ETAD	ETAO	ETAH	ETAR	ETAB	1-THDF	1-WFTT	1-WFTQ	ADVC
15.0	0.640	0.645	0.985	1.005	0.650	0.990	1.005	1.010	1.100
16.0	0.630	0.645	0.985	0.995	0.645	0.985	1.000	1.000	1.100
17.0	0.625	0.645	0.975	0.990	0.640	0.970	0.995	0.995	1.100
18.0	0.615	0.645	0.965	0.985	0.635	0.960	0.995	0.990	1.100
19.0	0.605	0.645	0.950	0.985	0.635	0.945	0.995	0.990	1.100
20.0	0.600	0.645	0.940	0.985	0.635	0.935	0.995	0.990	1.100
21.0	0.595	0.645	0.930	0.990	0.640	0.925	0.995	0.990	1.100
22.0	0.590	0.650	0.925	0.990	0.640	0.915	0.990	0.990	1.100
23.0	0.590	0.650	0.920	0.990	0.640	0.910	0.990	0.990	1.100
24.0	0.590	0.650	0.920	0.995	0.645	0.910	0.990	0.990	1.100
25.0	0.595	0.650	0.920	0.995	0.645	0.905	0.990	0.985	1.100
26.0	0.595	0.650	0.920	0.995	0.645	0.905	0.985	0.985	1.100
27.0	0.595	0.650	0.920	0.995	0.645	0.905	0.985	0.985	1.100
28.0	0.595	0.645	0.925	0.995	0.645	0.910	0.985	0.980	1.100
29.0	0.595	0.645	0.930	0.995	0.645	0.910	0.980	0.980	1.100
30.0	0.600	0.645	0.930	0.995	0.640	0.910	0.980	0.980	1.100
31.0	0.600	0.645	0.935	0.990	0.640	0.915	0.975	0.975	1.100
32.0	0.600	0.645	0.940	0.990	0.640	0.920	0.975	0.975	1.100
33.0	0.605	0.645	0.945	0.990	0.640	0.920	0.975	0.970	1.100
34.0	0.610	0.650	0.950	0.985	0.640	0.925	0.970	0.970	1.100
35.0	0.610	0.655	0.955	0.980	0.640	0.925	0.970	0.965	1.095
36.0	0.620	0.660	0.960	0.980	0.645	0.930	0.970	0.965	1.090
37.0	0.625	0.665	0.960	0.975	0.650	0.930	0.965	0.960	1.085
38.0	0.630	0.670	0.960	0.975	0.655	0.930	0.965	0.960	1.075
39.0	0.635	0.675	0.960	0.975	0.660	0.930	0.965	0.960	1.070

Table A25. HSS HCRSP Resistance & Powering Comparisons, Three Tested Displacements, F:A RPM = 1:1

HSS-HCRSP Resistance & Powering Comparisons at Three Tested Displacements

Fwd-to-Aft Prop Ratio 1:1

	Design (DES) Displacement			Heavy (HVY) Displacement			Light (LITE) Displacement		
VS (kts)	PE (hP)	PD (hP)	RPM	PE (hP)	PD (hP)	RPM	PE (hP)	PD (hP)	RPM
15	7390	10593	42.7	8022	11487	43.0	7381	10559	42.4
16	8807	12195	45.1	9652	13766	45.7	8704	11877	44.8
17	10401	14211	47.6	11480	16400	48.5	10144	13477	47.1
18	12186	16606	50.1	13488	19361	51.3	11720	15634	49.5
19	14116	19322	52.7	15676	22622	54.1	13461	18280	52.0
20	16264	22356	55.3	18063	26151	56.9	15401	21400	54.6
21	18625	25718	58.0	20678	29946	59.6	17577	24929	57.2
22	21232	29345	60.6	23555	33969	62.3	20021	28795	59.9
23	24110	33193	63.2	26723	38201	65.0	22755	32941	62.5
24	27276	37271	65.8	30195	42725	67.6	25789	36855	65.2
25	30726	41614	68.3	33962	47465	70.2	29117	41140	67.8
26	34441	46289	70.9	37999	52478	72.8	32720	45600	70.4
27	38391	51300	73.4	42266	57919	75.4	36577	50465	73.1
28	42545	56687	76.0	46727	63749	77.9	40667	55994	75.6
29	46891	62545	78.6	51364	70098	80.5	44991	61847	78.2
30	51459	69108	81.2	56208	77184	83.1	49580	68217	80.9
31	56335	76400	83.9	61356	85001	85.8	54513	75263	83.5
32	61687	84612	86.7	66993	93923	88.6	59930	82709	86.2
33	67770	94097	89.6	73403	104161	91.4	66033	91096	89.0
34	74926	104971	92.5	80966	115952	94.4	73094	100905	91.8
35	83558	117769	95.6	90132	129526	97.6	81432	112448	94.9
36	94100	132726	98.9	101384	145584	100.9	91399	126248	98.1
37	106949	150336	102.5	115167	164301	104.6	103335	142987	101.5
38	122400	171151	106.3	131815	186553	108.4	117520	163209	105.3
39	140564	196111	110.4	151468	212754	112.4	134122	187932	109.4
40	161309	225735	114.9	174007	243775	116.8	153138	218418	114.1
41	184243	260972	119.7	199051	280244	121.5	174352	255908	119.4
42	209306	303403	125.1	227222	323355	126.5	197330	302720	125.4

Table A25. HSS HCRSP Resistance & Powering Comparisons, Three Tested Displacements, F:A RPM = 1:1 - continued

HSS-HCRSP Resistance & Powering Comparisons at Three Tested Displacements (continued)

Fwd-to-Aft Prop Ratio 1:1

	HVY / DES			LITE / DES		
VS (kts)	PE ratio	PD ratio	RPM ratio	PE ratio	PD ratio	RPM ratio
15	1.086	1.084	1.007	0.999	0.997	0.993
16	1.096	1.129	1.013	0.988	0.974	0.993
17	1.104	1.154	1.019	0.975	0.948	0.989
18	1.107	1.166	1.024	0.962	0.941	0.988
19	1.111	1.171	1.027	0.954	0.946	0.987
20	1.111	1.170	1.029	0.947	0.957	0.987
21	1.110	1.164	1.028	0.944	0.969	0.986
22	1.109	1.158	1.028	0.943	0.981	0.988
23	1.108	1.151	1.028	0.944	0.992	0.989
24	1.107	1.146	1.027	0.945	0.989	0.991
25	1.105	1.141	1.028	0.948	0.989	0.993
26	1.103	1.134	1.027	0.950	0.985	0.993
27	1.101	1.129	1.027	0.953	0.984	0.996
28	1.098	1.125	1.025	0.956	0.988	0.995
29	1.095	1.121	1.024	0.959	0.989	0.995
30	1.092	1.117	1.023	0.963	0.987	0.996
31	1.089	1.113	1.023	0.968	0.985	0.995
32	1.086	1.110	1.022	0.972	0.978	0.994
33	1.083	1.107	1.020	0.974	0.968	0.993
34	1.081	1.105	1.021	0.976	0.961	0.992
35	1.079	1.100	1.021	0.975	0.955	0.993
36	1.077	1.097	1.020	0.971	0.951	0.992
37	1.077	1.093	1.020	0.966	0.951	0.990
38	1.077	1.090	1.020	0.960	0.954	0.991
39	1.078	1.085	1.018	0.954	0.958	0.991
40	1.079	1.080	1.017	0.949	0.968	0.993
41	1.080	1.074	1.015	0.946	0.981	0.997
42	1.086	1.066	1.011	0.943	0.998	1.002
	1.093	1.121	1.022	0.960	0.972	0.992

Table A26. HSS HCRSP Resistance & Powering Comparisons, Model Test Results vs. Pre-Test Estimate, DES Displacement, F:A RPM = 1:1

HSS-HCRSP Resistance & Powering Comparisons Model Test Results vs. Pre-Test Estimate

Design (DES) Displacement; Fwd-to-Aft Prop Ratio 1:1

	Pre-Test Estimate			Model Test Results			Pre-Test / Model Test		
VS (kts)	PE (hP)	PD (hP)	RPM	PE (hP)	PD (hP)	RPM	PE ratio	PD ratio	RPM ratio
15	7262	9867	42.7	7390	10593	42.7	0.983	0.931	1.000
16	8665	11629	45.2	8807	12195	45.1	0.984	0.954	1.002
17	10230	13631	47.8	10401	14211	47.6	0.984	0.959	1.004
18	11967	15899	50.4	12186	16606	50.1	0.982	0.957	1.007
19	13865	18410	53.1	14116	19322	52.7	0.982	0.953	1.008
20	15938	21220	55.8	16264	22356	55.3	0.980	0.949	1.010
21	18216	24349	58.6	18625	25718	58.0	0.978	0.947	1.010
22	20743	27819	61.2	21232	29345	60.6	0.977	0.948	1.011
23	23555	31764	64.0	24110	33193	63.2	0.977	0.957	1.013
24	26680	36231	66.8	27276	37271	65.8	0.978	0.972	1.015
25	30123	41113	69.5	30726	41614	68.3	0.980	0.988	1.018
26	33879	46487	72.2	34441	46289	70.9	0.984	1.004	1.019
27	37897	52436	75.1	38391	51300	73.4	0.987	1.022	1.023
28	42156	58765	77.9	42545	56687	76.0	0.991	1.037	1.025
29	46613	65371	80.6	46891	62545	78.6	0.994	1.045	1.026
30	51268	72422	83.4	51459	69108	81.2	0.996	1.048	1.027
31	56199	79756	86.1	56335	76400	83.9	0.998	1.044	1.027
32	61537	87743	88.9	61687	84612	86.7	0.998	1.037	1.026
33	67537	96630	91.8	67770	94097	89.6	0.997	1.027	1.025
34	74509	106433	94.6	74926	104971	92.5	0.994	1.014	1.023
35	82905	118151	97.7	83558	117769	95.6	0.992	1.003	1.022
36	93151	132372	100.9	94100	132726	98.9	0.990	0.997	1.021
37	105708	149094	104.3	106949	150336	102.5	0.988	0.992	1.018
38	120887	169588	108.0	122400	171151	106.3	0.988	0.991	1.016
39	138863	193931	112.1	140564	196111	110.4	0.988	0.989	1.015
40				161309	225735	114.9			
41				184243	260972	119.7			
42				209306	303403	125.1			
							0.987	0.991	1.016

Table A27. HSS HCRSP Resistance & Powering Comparisons with vs. without Stern Flap, DES Displacement, F:A RPM = 1:1

HSS-HCRSP Resistance & Powering Comparisons w/wo Stern Flap

Design (DES) Displacement; Fwd-to-Aft Prop Ratio 1:1

	Stern Flap Installed			Baseline Transom (No Flap)			Stern Flap / Baseline		
VS (kts)	PE (hP)	PD (hP)	RPM	PE (hP)	PD (hP)	RPM	PE ratio	PD ratio	RPM ratio
15	7390	10593	42.7	7272	10340	42.7	1.016	1.024	1.000
16	8807	12195	45.1	8699	12271	45.2	1.012	0.994	0.998
17	10401	14211	47.6	10281	14613	47.8	1.012	0.972	0.996
18	12186	16606	50.1	12050	17246	50.4	1.011	0.963	0.994
19	14116	19322	52.7	14033	20379	53.1	1.006	0.948	0.992
20	16264	22356	55.3	16249	23810	55.8	1.001	0.939	0.991
21	18625	25718	58.0	18686	27553	58.4	0.997	0.933	0.993
22	21232	29345	60.6	21388	31562	61.1	0.993	0.930	0.992
23	24110	33193	63.2	24405	35816	63.8	0.988	0.927	0.991
24	27276	37271	65.8	27706	40359	66.4	0.984	0.923	0.991
25	30726	41614	68.3	31281	45127	69.1	0.982	0.922	0.988
26	34441	46289	70.9	35101	50154	71.7	0.981	0.923	0.989
27	38391	51300	73.4	39161	55531	74.4	0.980	0.924	0.987
28	42545	56687	76.0	43579	61331	77.0	0.976	0.924	0.987
29	46891	62545	78.6	48174	67647	79.7	0.973	0.925	0.986
30	51459	69108	81.2	53093	74447	82.4	0.969	0.928	0.985
31	56335	76400	83.9	58382	82114	85.2	0.965	0.930	0.985
32	61687	84612	86.7	64385	90800	88.1	0.958	0.932	0.984
33	67770	94097	89.6	71082	100554	91.0	0.953	0.936	0.985
34	74926	104971	92.5	78797	111893	94.0	0.951	0.938	0.984
35	83558	117769	95.6	87903	125062	97.2	0.951	0.942	0.984
36	94100	132726	98.9	98551	140581	100.5	0.955	0.944	0.984
37	106949	150336	102.5	111620	158792	104.1	0.958	0.947	0.985
38	122400	171151	106.3	127641	180336	107.9	0.959	0.949	0.985
39	140564	196111	110.4	146873	205786	112.0	0.957	0.953	0.986
40	161309	225735	114.9	168680	236237	116.4	0.956	0.956	0.987
41	184243	260972	119.7	193062	272623	121.2	0.954	0.957	0.988
42	209306	303403	125.1	219163	315926	126.3	0.955	0.960	0.990
							0.977	0.944	0.989

Table A28. HSS HCRSP Powering Comparisons for Variations in Fwd-to-Aft Propeller RPM Ratios, DES Displacement

HSS-HCRSP Powering Comparisons for Variations in Fwd-to-Aft Propeller Ratios

Design (DES) Displacement; Equivalent DES Resistance (w/Flap)

		Fwd:Aft = 1.05:1			Fwd:Aft = 1.025:1			Fwd:Aft = 1:1	
VS (kts)	PE (hP)	PD (hP)	RPM Fwd	RPM Aft	PD (hP)	RPM Fwd	RPM Aft	PD (hP)	RPM
15	7390	10567	43.4	41.4	10152	43.3	42.2	10593	42.7
16	8807	11832	45.7	43.5	11479	45.8	44.6	12195	45.1
17	10401	13621	48.0	45.7	13322	48.2	47.0	14211	47.6
18	12186	15969	50.4	48.0	15689	50.8	49.5	16606	50.1
19	14116	18787	53.1	50.5	18467	53.2	51.9	19322	52.7
20	16264	22075	55.8	53.1	21714	55.9	54.5	22356	55.3
21	18625	25758	58.5	55.7	25341	58.5	57.0	25718	58.0
22	21232	29746	61.3	58.4	29288	61.1	59.6	29345	60.6
23	24110	34060	64.1	61.0	33556	63.7	62.2	33193	63.2
24	27276	38563	66.8	63.6	38046	66.4	64.7	37271	65.8
25	30726	43240	69.5	66.2	42816	69.0	67.3	41614	68.3
26	34441	48144	72.2	68.7	47856	71.6	69.8	46289	70.9
27	38391	53209	74.8	71.2	53113	74.2	72.3	51300	73.4
28	42545	58578	77.4	73.7	58694	76.8	74.8	56687	76.0
29	46891	64274	79.9	76.1	64726	79.4	77.4	62545	78.6
30	51459	70369	82.5	78.5	71225	82.0	80.0	69108	81.2
31	56335	77117	85.1	81.0	78332	84.7	82.6	76400	83.9
32	61687	84688	87.7	83.5	86331	87.5	85.3	84612	86.7
33	67770	93431	90.4	86.1	95347	90.3	88.1	94097	89.6
34	74926	103570	93.3	88.9	105812	93.3	91.0	104971	92.5
35	83558	115685	96.4	91.8	118041	96.4	94.0	117769	95.6
36	94100	130211	99.8	95.0	132358	99.7	97.2	132726	98.9
37	106949	147873	103.5	98.6	149505	103.3	100.7	150336	102.5
38	122400	169325	107.6	102.4	169743	107.0	104.4	171151	106.3
39	140564	195904	112.1	106.7	195123	111.4	108.6	196111	110.4
40	161309	228288	117.2	111.6	226264	116.5	113.5	225735	114.9
41	184243	268527	122.9	116.9	265844	122.4	119.4	260972	119.7
42	209306	317734	129.2	123.0	313642	129.0	125.8	303403	125.1

Table A28. HSS HCRSP Powering Comparisons for Variations in Fwd-to-Aft Propeller RPM Ratios, DES Displacement - continued

HSS-HCRSP Powering Comparisons for Variations in Fwd-to-Aft Propeller Ratios (continued)
Design (DES) Displacement; Equivalent DES Resistance (w/Flap)

		Fwd:Aft = 1:1		Fwd:Aft = 0.975:1			Fwd:Aft = 0.95:1		
VS (kts)	PE (hP)	PD (hP)	RPM	PD (hP)	RPM Fwd	RPM Aft	PD (hP)	RPM Fwd	RPM Aft
15	7390	10593	42.7	10576	42.3	43.4	10628	42.1	44.3
16	8807	12195	45.1	12152	44.6	45.7	12632	44.4	46.7
17	10401	14211	47.6	14132	46.9	48.1	14838	46.9	49.3
18	12186	16606	50.1	16497	49.4	50.7	17248	49.3	51.9
19	14116	19322	52.7	19236	52.0	53.3	19883	51.9	54.6
20	16264	22356	55.3	22319	54.6	55.9	22744	54.4	57.3
21	18625	25718	58.0	25887	57.2	58.7	26208	57.1	60.0
22	21232	29345	60.6	29549	59.9	61.4	29914	59.6	62.8
23	24110	33193	63.2	33879	62.6	64.2	33722	62.2	65.5
24	27276	37271	65.8	38324	65.2	66.9	37895	64.8	68.2
25	30726	41614	68.3	42941	67.9	69.6	42448	67.4	70.9
26	34441	46289	70.9	47929	70.5	72.3	47430	70.0	73.6
27	38391	51300	73.4	53123	73.1	74.9	52832	72.6	76.4
28	42545	56687	76.0	58598	75.7	77.6	58754	75.2	79.1
29	46891	62545	78.6	64434	78.2	80.2	65238	77.8	81.9
30	51459	69108	81.2	70927	80.9	82.9	72362	80.4	84.6
31	56335	76400	83.9	78070	83.5	85.6	80302	83.1	87.4
32	61687	84612	86.7	85783	86.1	88.3	88720	85.8	90.3
33	67770	94097	89.6	94683	88.9	91.1	98306	88.5	93.1
34	74926	104971	92.5	104894	91.7	94.1	108700	91.3	96.1
35	83558	117769	95.6	116875	94.8	97.1	119763	94.2	99.1
36	94100	132726	98.9	131007	98.0	100.4	133344	97.2	102.3
37	106949	150336	102.5	147992	101.4	103.9	148710	100.4	105.6
38	122400	171151	106.3	167166	105.1	107.8	166051	103.7	109.1
39	140564	196111	110.4	189611	109.2	111.9	186201	107.3	112.9
40	161309	225735	114.9	216715	113.7	116.5	210331	111.0	116.8
41	184243	260972	119.7	247329	118.3	121.2	236753	114.3	120.2
42	209306	303403	125.1	282425	123.7	126.7	265374	118.3	124.4

Table A28. HSS HCRSP Powering Comparisons for Variations in Fwd-to-Aft Propeller RPM Ratios, DES Displacement - continued

HSS-HCRSP Powering Comparisons for Variations in Fwd-to-Aft Propeller Ratios (continued)
Design (DES) Displacement; Equivalent DES Resistance (w/Flap)

	1.05:1 / 1:1		1.025:1 / 1:1		0.975:1 / 1:1		0.95:1 / 1:1	
VS (kts)	PD ratio	RPM ratio	PD ratio	RPM ratio	PD ratio	RPM ratio	PD ratio	RPM ratio
15	0.998	0.993	0.958	1.001	0.998	1.004	1.003	1.012
16	0.970	0.989	0.941	1.002	0.996	1.001	1.036	1.010
17	0.958	0.984	0.937	1.000	0.994	0.998	1.044	1.011
18	0.962	0.982	0.945	1.001	0.993	0.999	1.039	1.010
19	0.972	0.983	0.956	0.997	0.996	0.999	1.029	1.010
20	0.987	0.985	0.971	0.998	0.998	0.999	1.017	1.010
21	1.002	0.984	0.985	0.996	1.007	0.999	1.019	1.009
22	1.014	0.988	0.998	0.996	1.007	1.001	1.019	1.010
23	1.026	0.990	1.011	0.996	1.021	1.003	1.016	1.010
24	1.035	0.991	1.021	0.996	1.028	1.004	1.017	1.011
25	1.039	0.993	1.029	0.998	1.032	1.007	1.020	1.012
26	1.040	0.994	1.034	0.997	1.035	1.007	1.025	1.013
27	1.037	0.995	1.035	0.998	1.036	1.008	1.030	1.015
28	1.033	0.994	1.035	0.997	1.034	1.009	1.036	1.015
29	1.028	0.992	1.035	0.997	1.030	1.008	1.043	1.016
30	1.018	0.991	1.031	0.998	1.026	1.009	1.047	1.016
31	1.009	0.990	1.025	0.997	1.022	1.008	1.051	1.016
32	1.001	0.987	1.020	0.997	1.014	1.006	1.049	1.016
33	0.993	0.985	1.013	0.996	1.006	1.004	1.045	1.013
34	0.987	0.985	1.008	0.996	0.999	1.004	1.036	1.013
35	0.982	0.984	1.002	0.996	0.992	1.004	1.017	1.011
36	0.981	0.985	0.997	0.995	0.987	1.003	1.005	1.009
37	0.984	0.986	0.994	0.995	0.984	1.001	0.989	1.005
38	0.989	0.988	0.992	0.994	0.977	1.001	0.970	1.001
39	0.999	0.991	0.995	0.996	0.967	1.001	0.949	0.997
40	1.011	0.996	1.002	1.001	0.960	1.002	0.932	0.991
41	1.029	1.002	1.019	1.010	0.948	1.000	0.907	0.980
42	1.047	1.008	1.034	1.018	0.931	1.001	0.875	0.970
	1.005	0.990	1.001	0.999	1.001	1.003	1.009	1.008

Table A29. HSS HCRSP Powering Comparisons for Variations in Pod Alignment Angle, DES Displacement, F:A RPM = 1:1

HSS-HCRSP Powering Comparisons for Variations in Pod Alignment Angle*

Design (DES) Displacement; Equivalent DES Resistance (w/Flap); Fwd-to-Aft Prop Ratio 1:1

		LE 2.5° Inbd		Aligned		LE 2.5° Otbd		LE 5° Otbd	
VS (kts)	PE (hP)	PD (hP)	RPM	PD (hP)	RPM	PD (hP)	RPM	PD (hP)	RPM
15	7390	11217	43.1	10593	42.7	11230	42.4	11364	43.5
16	8807	13074	45.7	12195	45.1	12472	44.9	13336	46.0
17	10401	15292	48.3	14211	47.6	14251	47.4	15681	48.7
18	12186	17884	50.9	16606	50.1	16539	50.1	18421	51.3
19	14116	20817	53.6	19322	52.7	19293	52.7	21493	54.0
20	16264	24107	56.2	22356	55.3	22473	55.4	24901	56.6
21	18625	27706	58.9	25718	58.0	26042	58.0	28619	59.3
22	21232	31620	61.5	29345	60.6	29961	60.6	32611	61.9
23	24110	35859	64.1	33193	63.2	34291	63.3	36852	64.6
24	27276	40451	66.7	37271	65.8	38898	66.0	41430	67.2
25	30726	45348	69.3	41614	68.3	43957	68.6	46270	69.8
26	34441	50644	71.9	46289	70.9	49201	71.3	51405	72.4
27	38391	56380	74.5	51300	73.4	54660	73.9	56868	75.0
28	42545	62597	77.1	56687	76.0	60530	76.4	62851	77.6
29	46891	69395	79.8	62545	78.6	66816	79.0	69333	80.3
30	51459	76912	82.5	69108	81.2	73632	81.7	76430	82.9
31	56335	85219	85.3	76400	83.9	81231	84.4	84218	85.7
32	61687	94499	88.1	84612	86.7	89565	87.2	93132	88.5
33	67770	104978	91.1	94097	89.6	99049	90.1	103206	91.4
34	74926	116935	94.1	104971	92.5	109979	93.1	114636	94.4
35	83558	130624	97.3	117769	95.6	122455	96.2	127964	97.6
36	94100	146488	100.7	132726	98.9	136404	99.5	143419	100.9
37	106949	164711	104.3	150336	102.5	153541	103.0	161629	104.5
38	122400	186054	108.1	171151	106.3	173924	106.7	182834	108.3
39	140564	210672	112.1	196111	110.4	198243	110.8	207776	112.3
40	161309	239653	116.4	225735	114.9	227357	115.3	237286	116.6
41	184243	273524	120.9	260972	119.7	262205	120.0	272034	121.2
42	209306	312870	125.8	303403	125.1	304094	125.3	313187	126.1

*Alignment Angle: Both Pods rotated either LE inboard or LE outboard (mirrored) relative to the design alignment angle of 1° LE inboard (in line with forward propeller shaftlines).

Table A29. HSS HCRSP Powering Comparisons for Variations in Pod Alignment Angle, DES Displacement, F:A RPM = 1:1 - continued

HSS-HCRSP Powering Comparisons for Variations in Pod Alignment Angle* (continued)
Design (DES) Displacement; Equivalent DES Resistance (w/Flap); Fwd-to-Aft Prop Ratio 1:1

	2.5° Inbd / Aligned		2.5° Otbd / Aligned		5° Otbd / Aligned	
VS (kts)	PD ratio	RPM ratio	PD ratio	RPM ratio	PD ratio	RPM ratio
15	1.059	1.009	1.060	0.993	1.073	1.019
16	1.072	1.013	1.023	0.996	1.094	1.020
17	1.076	1.015	1.003	0.996	1.103	1.023
18	1.077	1.016	0.996	1.000	1.109	1.024
19	1.077	1.017	0.998	1.000	1.112	1.025
20	1.078	1.016	1.005	1.002	1.114	1.024
21	1.077	1.016	1.013	1.000	1.113	1.022
22	1.078	1.015	1.021	1.000	1.111	1.021
23	1.080	1.014	1.033	1.002	1.110	1.022
24	1.085	1.014	1.044	1.003	1.112	1.021
25	1.090	1.015	1.056	1.004	1.112	1.022
26	1.094	1.014	1.063	1.006	1.111	1.021
27	1.099	1.015	1.065	1.007	1.109	1.022
28	1.104	1.014	1.068	1.005	1.109	1.021
29	1.110	1.015	1.068	1.005	1.109	1.022
30	1.113	1.016	1.065	1.006	1.106	1.021
31	1.115	1.017	1.063	1.006	1.102	1.021
32	1.117	1.016	1.059	1.006	1.101	1.021
33	1.116	1.017	1.053	1.006	1.097	1.020
34	1.114	1.017	1.048	1.006	1.092	1.021
35	1.109	1.018	1.040	1.006	1.087	1.021
36	1.104	1.018	1.028	1.006	1.081	1.020
37	1.096	1.018	1.021	1.005	1.075	1.020
38	1.087	1.017	1.016	1.004	1.068	1.019
39	1.074	1.015	1.011	1.004	1.059	1.017
40	1.062	1.013	1.007	1.003	1.051	1.015
41	1.048	1.010	1.005	1.003	1.042	1.013
42	1.031	1.006	1.002	1.002	1.032	1.008
	1.087	1.015	1.033	1.003	1.093	1.020

Table A30. HSS HCRSP Powering Comparisons for Variations in Pod Steering Angle, DES Displacement, F:A RPM = 1:1

HSS-HCRSP Powering Comparisons for Variations in Pod Steering Angle*

Design (DES) Displacement; Equivalent DES Resistance (w/Flap); Fwd-to-Aft Prop Ratio 1:1

		Aligned		LE 2.5° to Stbd		LE 5° to Stbd		2.5° Stbd / Aligned		5° Stbd / Aligned	
VS (kts)	PE (hP)	PD (hP)	RPM	PD (hP)	RPM	PD (hP)	RPM	PD ratio	RPM ratio	PD ratio	RPM ratio
15	7390	10593	42.7	11342	43.2	12050	43.8	1.071	1.012	1.138	1.026
16	8807	12195	45.1	12962	45.7	13792	46.3	1.063	1.013	1.131	1.027
17	10401	14211	47.6	15055	48.3	16072	48.9	1.059	1.015	1.131	1.027
18	12186	16606	50.1	17621	50.9	18860	51.6	1.061	1.016	1.136	1.030
19	14116	19322	52.7	20591	53.6	22083	54.3	1.066	1.017	1.143	1.030
20	16264	22356	55.3	23935	56.3	25736	57.0	1.071	1.018	1.151	1.031
21	18625	25718	58.0	27645	58.9	29751	59.7	1.075	1.016	1.157	1.029
22	21232	29345	60.6	31662	61.5	34107	62.4	1.079	1.015	1.162	1.030
23	24110	33193	63.2	36038	64.2	38730	65.1	1.086	1.016	1.167	1.030
24	27276	37271	65.8	40687	66.8	43664	67.8	1.092	1.015	1.172	1.030
25	30726	41614	68.3	45650	69.4	48892	70.4	1.097	1.016	1.175	1.031
26	34441	46289	70.9	50946	72.0	54406	73.1	1.101	1.016	1.175	1.031
27	38391	51300	73.4	56609	74.6	60233	75.7	1.103	1.016	1.174	1.031
28	42545	56687	76.0	62610	77.1	66352	78.4	1.104	1.014	1.170	1.032
29	46891	62545	78.6	69142	79.8	73064	81.0	1.105	1.015	1.168	1.031
30	51459	69108	81.2	76300	82.5	80310	83.7	1.104	1.016	1.162	1.031
31	56335	76400	83.9	84165	85.2	88281	86.5	1.102	1.015	1.156	1.031
32	61687	84612	86.7	92905	88.0	97194	89.3	1.098	1.015	1.149	1.030
33	67770	94097	89.6	102813	90.8	107363	92.2	1.093	1.013	1.141	1.029
34	74926	104971	92.5	114087	93.8	119001	95.2	1.087	1.014	1.134	1.029
35	83558	117769	95.6	127127	97.0	132656	98.4	1.079	1.015	1.126	1.029
36	94100	132726	98.9	142239	100.3	148508	101.7	1.072	1.014	1.119	1.028
37	106949	150336	102.5	159784	103.8	167450	105.3	1.063	1.013	1.114	1.027
38	122400	171151	106.3	180413	107.6	189821	109.1	1.054	1.012	1.109	1.026
39	140564	196111	110.4	205003	111.6	216661	113.2	1.045	1.011	1.105	1.025
40	161309	225735	114.9	233888	116.0	248563	117.8	1.036	1.010	1.101	1.025
41	184243	260972	119.7	268078	120.6	287521	122.8	1.027	1.008	1.102	1.026
42	209306	303403	125.1	308884	125.5	334260	128.3	1.018	1.003	1.102	1.026
								1.075	1.014	1.142	1.029

*Steering Angle: Both Pods rotated LE to starboard relative to the design alignment angle of 1° LE inboard (in line with forward propeller shaftlines).

Table A31. HSS HCRSP forward-to-aft propeller rpm ratio scheduling for optimal performance and for best performance within propulsion system capabilities

HSS-HCRSP Powering Comparisons for F:A RPM Ratio Scheduling

	Optimal Perfomance RPM Scheduling					Best Performance within Propulsion System Capabilities				
VS (kts)	F:A Ratio	PD (hP)	Fwd RPM	Aft RPM	RPM-Avg	F:A Ratio	PD (hP)	Fwd RPM	Aft RPM	RPM-Avg
15	1.025:1	10152	43.3	42.2	42.8	1.025:1	10152	43.3	42.2	42.8
16	1.025:1	11479	45.8	44.6	45.2	1.025:1	11479	45.8	44.6	45.2
17	1.025:1	13322	48.2	47	47.6	1.025:1	13322	48.2	47	47.6
18	1.025:1	15689	50.8	49.5	50.2	1.025:1	15689	50.8	49.5	50.2
19	1.025:1	18467	53.2	51.9	52.6	1.025:1	18467	53.2	51.9	52.6
20	1.025:1	21714	55.9	54.5	55.2	1.025:1	21714	55.9	54.5	55.2
21	1.025:1	25341	58.5	57	57.8	1.025:1	25341	58.5	57	57.8
22	1.025:1	29288	61.1	59.6	60.4	1.025:1	29288	61.1	59.6	60.4
23	1:1	33193	63.2	63.2	63.2	1:1	33193	63.2	63.2	63.2
24	1:1	37271	65.8	65.8	65.8	1:1	37271	65.8	65.8	65.8
25	1:1	41614	68.3	68.3	68.3	1:1	41614	68.3	68.3	68.3
26	1:1	46289	70.9	70.9	70.9	1:1	46289	70.9	70.9	70.9
27	1:1	51300	73.4	73.4	73.4	1:1	51300	73.4	73.4	73.4
28	1:1	56687	76	76	76.0	1:1	56687	76	76	76.0
29	1:1	62545	78.6	78.6	78.6	1:1	62545	78.6	78.6	78.6
30	1:1	69108	81.2	81.2	81.2	1:1	69108	81.2	81.2	81.2
31	1:1	76400	83.9	83.9	83.9	1:1	76400	83.9	83.9	83.9
32	1:1	84612	86.7	86.7	86.7	1:1	84612	86.7	86.7	86.7
33	1.05:1	93431	90.4	86.1	88.3	1.05:1	93431	90.4	86.1	88.3
34	1.05:1	103570	93.3	88.9	91.1	1.05:1	103570	93.3	88.9	91.1
35	1.05:1	115685	96.4	91.8	94.1	1.05:1	115685	96.4	91.8	94.1
36	1.05:1	130211	99.8	95	97.4	1.05:1	130211	99.8	95	97.4
37	1.05:1	147873	103.5	98.6	101.1	1.05:1	147873	103.5	98.6	101.1
38	0.95:1	166051	103.7	109.1	106.4	1.05:1	169325	107.6	102.4	105.0
39	0.95:1	186201	107.3	112.9	110.1	1.025:1	195123	111.4	108.6	110.0
40	0.95:1	210331	111	116.8	113.9	-	-			
41	0.95:1	236753	114.3	120.2	117.3	-	-			
42	0.95:1	265374	118.3	124.4	121.4	-	-			

Table A32. HSS HCRSP Model 5653-3A measurement uncertainties

25 knot Ship Speed	Condition: DES						
Measurement	Units	Nominal Mean	Bias Error ±	Precision Error ±	Uncertainty* (units) ±	(percent) ±	Four Shafts (percent) ±
Speed	ft/sec	7.25	0.002	0.002	0.003	0.04	-
Resistance	lbf	16.86	0.059	0.179	0.189	**1.12**	-
Shaft (Inbd-Fwd) Rev Rate	RPM	400.69	0.005	3.44	3.44	0.86	-
Pod (Otbd-Aft) Rev Rate - average	RPM	399.59	0.005	6.61	6.61	1.65	1.26
Shaft (Inbd-Fwd) Thrust - combined	lbf	6.64	0.056	0.317	0.322	4.85	-
Pod (Otbd-Aft) Thrust - combined	lbf	4.88	0.056	0.232	0.239	4.89	4.87
Shaft (Inbd-Fwd) Torque - combined	lbf-in	18.30	0.098	0.729	0.736	4.02	-
Pod (Otbd-Aft) Torque - combined	lbf-in	10.56	0.098	0.398	0.409	3.88	3.95
Shaft (Inbd-Fwd) Power - combined	hP	0.116	0.0006	0.0047	0.0048	4.11	-
Pod (Otbd-Aft) Power - combined	hP	0.067	0.0006	0.0028	0.0028	4.21	**4.16**

39 knot Ship Speed	Condition: DES						
Measurement	Units	Nominal Mean	Bias Error ±	Precision Error ±	Uncertainty* (units) ±	(percent) ±	Four Props (percent) ±
Speed	ft/sec	11.32	0.003	0.002	0.004	0.04	-
Resistance	lbf	44.21	0.068	0.340	0.347	**0.79**	-
Shaft (Inbd-Fwd) Rev Rate	RPM	650.18	0.006	2.45	2.45	0.38	-
Pod (Otbd-Aft) Rev Rate - average	RPM	651.25	0.006	4.99	4.99	0.77	0.57
Shaft (Inbd-Fwd) Thrust - combined	lbf	19.83	0.060	1.179	1.181	5.95	-
Pod (Otbd-Aft) Thrust - combined	lbf	14.59	0.060	0.486	0.490	3.36	4.65
Shaft (Inbd-Fwd) Torque - combined	lbf-in	52.33	0.108	2.420	2.422	4.63	-
Pod (Otbd-Aft) Torque - combined	lbf-in	31.10	0.108	0.922	0.928	2.98	3.81
Shaft (Inbd-Fwd) Power - combined	hP	0.540	0.0011	0.0250	0.0251	4.64	-
Pod (Otbd-Aft) Power - combined	hP	0.321	0.0011	0.0098	0.0099	3.08	**3.86**

Table A33a. Resistance & Powering Comparisons HSS Hybrid C-R Shaft-Pod (HCRSP) F:A propeller ratio = 1:1 vs. JHSS 4-Screw Baseline Shaft & Strut (BSS), DES Displacement

Resistance & Powering Comparisons HSS Hybrid C-R Shaft-Pod (HCRSP) vs. JHSS 4-Screw Baseline Shaft & Strut (BSS)
Design (DES) Displacement; Stern Flap Installed; HCRSP Fwd-to-Aft Prop Ratio 1:1

	HSS HCRSP			JHSS BSS			HSS HCRSP / JHSS BSS		
VS (kts)	PE (hP)	PD (hP)	RPM	PE (hP)	PD (hP)	RPM	PE ratio	PD ratio	RPM ratio
15	7390	10593	42.7	7868	12031	55.0	0.939	0.880	0.776
16	8807	12195	45.1	9334	14322	58.3	0.944	0.851	0.774
17	10401	14211	47.6	10962	16868	61.5	0.949	0.842	0.774
18	12186	16606	50.1	12759	19704	64.9	0.955	0.843	0.772
19	14116	19322	52.7	14709	22805	68.3	0.960	0.847	0.772
20	16264	22356	55.3	16868	26253	71.7	0.964	0.852	0.771
21	18625	25718	58.0	19298	30106	75.3	0.965	0.854	0.770
22	21232	29345	60.6	22025	34500	78.8	0.964	0.851	0.769
23	24110	33193	63.2	25058	39377	82.3	0.962	0.843	0.768
24	27276	37271	65.8	28387	44685	85.8	0.961	0.834	0.767
25	30726	41614	68.3	31987	50426	89.3	0.961	0.825	0.765
26	34441	46289	70.9	35824	56561	92.8	0.961	0.818	0.764
27	38391	51300	73.4	39865	63039	96.2	0.963	0.814	0.763
28	42545	56687	76.0	44090	69698	99.5	0.965	0.813	0.764
29	46891	62545	78.6	48505	76701	102.8	0.967	0.815	0.765
30	51459	69108	81.2	53157	83951	106.1	0.968	0.823	0.765
31	56335	76400	83.9	58151	91779	109.3	0.969	0.832	0.768
32	61687	84612	86.7	63654	100209	112.6	0.969	0.844	0.770
33	67770	94097	89.6	69902	109696	115.8	0.970	0.858	0.774
34	74926	104971	92.5	77197	120799	119.3	0.971	0.869	0.775
35	83558	117769	95.6	85888	133934	122.9	0.973	0.879	0.778
36	94100	132726	98.9	96351	149593	126.7	0.977	0.887	0.781
37	106949	150336	102.5	108950	168528	130.8	0.982	0.892	0.784
38	122400	171151	106.3	123990	190916	135.3	0.987	0.896	0.786
39	140564	196111	110.4	141663	217339	140.0	0.992	0.902	0.789
40	161309	225735	114.9	161993	247417	145.1	0.996	0.912	0.792
41	184243	260972	119.7	184792	280991	150.5	0.997	0.929	0.795
42	209306	303403	125.1	209631	317161	155.9	0.998	0.957	0.802
							0.969	0.860	0.775

Table A33b. Resistance & Powering Comparisons HSS Hybrid C-R Shaft-Pod (HCRSP) F:A propeller ratio varied vs. JHSS 4-Screw Baseline Shaft & Strut (BSS), DES Displacement

Resistance & Powering Comparisons HSS Hybrid C-R Shaft-Pod (HCRSP) vs. JHSS 4-Screw Baseline Shaft & Strut (BSS)
Design (DES) Displacement; Stern Flap Installed; HCRSP Fwd-to-Aft Prop Ratio Varried for 'Actual Capability' Best Performance

	HSS HCRSP				JHSS BSS			HSS HCRSP / JHSS BSS		
VS (kts)	PE (hP)	F:A Ratio	PD (hP)	RPM avg	PE (hP)	PD (hP)	RPM	PE ratio	PD ratio	RPM ratio
15	7390	1.025:1	10152	42.8	7868	12031	55.0	0.939	0.844	0.777
16	8807	1.025:1	11479	45.2	9334	14322	58.3	0.944	0.801	0.775
17	10401	1.025:1	13322	47.6	10962	16868	61.5	0.949	0.790	0.774
18	12186	1.025:1	15689	50.2	12759	19704	64.9	0.955	0.796	0.773
19	14116	1.025:1	18467	52.6	14709	22805	68.3	0.960	0.810	0.769
20	16264	1.025:1	21714	55.2	16868	26253	71.7	0.964	0.827	0.770
21	18625	1.025:1	25341	57.8	19298	30106	75.3	0.965	0.842	0.767
22	21232	1.025:1	29288	60.4	22025	34500	78.8	0.964	0.849	0.766
23	24110	1:1	33193	63.2	25058	39377	82.3	0.962	0.843	0.768
24	27276	1:1	37271	65.8	28387	44685	85.8	0.961	0.834	0.767
25	30726	1:1	41614	68.3	31987	50426	89.3	0.961	0.825	0.765
26	34441	1:1	46289	70.9	35824	56561	92.8	0.961	0.818	0.764
27	38391	1:1	51300	73.4	39865	63039	96.2	0.963	0.814	0.763
28	42545	1:1	56687	76.0	44090	69698	99.5	0.965	0.813	0.764
29	46891	1:1	62545	78.6	48505	76701	102.8	0.967	0.815	0.765
30	51459	1:1	69108	81.2	53157	83951	106.1	0.968	0.823	0.765
31	56335	1:1	76400	83.9	58151	91779	109.3	0.969	0.832	0.768
32	61687	1:1	84612	86.7	63654	100209	112.6	0.969	0.844	0.770
33	67770	1.05:1	93431	88.3	69902	109696	115.8	0.970	0.852	0.762
34	74926	1.05:1	103570	91.1	77197	120799	119.3	0.971	0.857	0.764
35	83558	1.05:1	115685	94.1	85888	133934	122.9	0.973	0.864	0.766
36	94100	1.05:1	130211	97.4	96351	149593	126.7	0.977	0.870	0.769
37	106949	1.05:1	147873	101.1	108950	168528	130.8	0.982	0.877	0.773
38	122400	1.05:1	169325	105.0	123990	190916	135.3	0.987	0.887	0.776
39	140564	1.025:1	195123	110.0	141663	217339	140.0	0.992	0.898	0.786
40	161309	-	-	-	161993	247417	145.1	0.996	-	-
41	184243	-	-	-	184792	280991	150.5	0.997	-	-
42	209306	-	-	-	209631	317161	155.9	0.998	-	-
								0.969	0.837	0.769

Table A34. Open propeller shaftline resistance comparisons HSS Twin-Screw vs. JHSS 4-Screw, DES Displacement

	JHSS-BSS Test Series				HSS-HCRSP Test Series				
VS (knots)	BareHull Exp14 DES PE (hp)	4-Screw DES Four Shafts Δ PE (hP)	Per Shaft Δ PE (hP)	Per Shaft (% Bare Hull)	2-Screw DES Twin Shafts Δ PE (hP)	Per Shaft Δ PE (hP)	Per Shaft (% Bare Hull)	Average Per Shaft Δ PE (hP)	Per Shaft (% Bare Hull)
15	5594	1668	417	7.5	863	431	7.7	424	7.6
16	6624	2040	510	7.7	1013	506	7.6	508	7.7
17	7788	2442	610	7.8	1164	582	7.5	596	7.7
18	9079	2887	722	7.9	1355	677	7.5	699	7.7
19	10509	3355	839	8.0	1593	797	7.6	818	7.8
20	12102	3836	959	7.9	1873	937	7.7	948	7.8
21	13889	4327	1082	7.8	2194	1097	7.9	1090	7.8
22	15905	4837	1209	7.6	2513	1257	7.9	1233	7.8
23	18174	5380	1345	7.4	2803	1402	7.7	1373	7.6
24	20707	5973	1493	7.2	3043	1521	7.3	1507	7.3
25	23494	6631	1658	7.1	3219	1610	6.9	1634	7.0
26	26509	7367	1842	6.9	3375	1687	6.4	1764	6.7
27	29716	8183	2046	6.9	3503	1751	5.9	1899	6.4
28	33078	9075	2269	6.9	3680	1840	5.6	2054	6.2
29	36581	10028	2507	6.9	3975	1987	5.4	2247	6.1
30	40248	11020	2755	6.8	4425	2213	5.5	2484	6.2
31	44166	12031	3008	6.8	5078	2539	5.7	2773	6.3
32	48496	13041	3260	6.7	5831	2916	6.0	3088	6.4
33	53490	14041	3510	6.6	6597	3298	6.2	3404	6.4
34	59478	15035	3759	6.3	7694	3847	6.5	3803	6.4
35	66855	16046	4011	6.0	8754	4377	6.5	4194	6.3
36	76039	17112	4278	5.6	9570	4785	6.3	4531	6.0
37	87418	18284	4571	5.2	10105	5052	5.8	4812	5.5
38	101274	19612	4903	4.8	10330	5165	5.1	5034	5.0
39	117717	21135	5284	4.5	10334	5167	4.4	5225	4.4
40	136626	22854	5713	4.2	10370	5185	3.8	5449	4.0
41	157629	24720	6180	3.9	10715	5358	3.4	5769	3.7
42	180182	26617	6654	3.7	11796	5898	3.3	6276	3.5
43	203766	28358	7090	3.5	13627	6813	3.3	6952	3.4
44	228320	29719	7430	3.3	15478	7739	3.4	7584	3.3
45	254968	30499	7625	3.0	15618	7809	3.1	7717	3.0

Table A35. Resistance & Powering Comparisons HSS Hybrid C-R Shaft-Pod (HCRSP) F:A propeller ratio varied vs. Simulated Twin-Screw, DES Displacement

Resistance & Powering Comparisons HSS Hybrid C-R Shaft-Pod (HCRSP) vs. Simulated HSS Twin-Screw

Design (DES) Displacement; Stern Flap Installed; HCRSP Fwd-to-Aft Prop Ratio Varried for 'Actual Capability' Best Performance

	HSS HCRSP				HSS Simulated Twin-Screw*			HSS HCRSP / HSS 2-Screw		
VS (kts)	PE (hP)	F:A Ratio	PD (hP)	RPM avg	PE (hP)	PD (hP)	RPM	PE ratio	PD ratio	RPM ratio
15	7390	1.025:1	10152	42.8	6772	10575	64.8	1.091	0.960	0.660
16	8807	1.025:1	11479	45.2	8007	12665	68.6	1.100	0.906	0.659
17	10401	1.025:1	13322	47.6	9431	15141	72.6	1.103	0.880	0.656
18	12186	1.025:1	15689	50.2	11026	17984	76.8	1.105	0.872	0.653
19	14116	1.025:1	18467	52.6	12746	21083	80.9	1.107	0.876	0.650
20	16264	1.025:1	21714	55.2	14667	24516	85.1	1.109	0.886	0.649
21	18625	1.025:1	25341	57.8	16830	28285	89.4	1.107	0.896	0.646
22	21232	1.025:1	29288	60.4	19234	32515	93.6	1.104	0.901	0.645
23	24110	1:1	33193	63.2	21840	36964	97.7	1.104	0.898	0.647
24	27276	1:1	37271	65.8	24702	41710	101.8	1.104	0.894	0.646
25	30726	1:1	41614	68.3	27799	46903	106.0	1.105	0.887	0.644
26	34441	1:1	46289	70.9	31154	52499	110.0	1.106	0.882	0.645
27	38391	1:1	51300	73.4	34726	58348	114.0	1.106	0.879	0.644
28	42545	1:1	56687	76.0	38388	64415	118.0	1.108	0.880	0.644
29	46891	1:1	62545	78.6	42362	70967	121.8	1.107	0.881	0.645
30	51459	1:1	69108	81.2	46601	77961	125.9	1.104	0.886	0.645
31	56335	1:1	76400	83.9	51248	85459	129.6	1.099	0.894	0.647
32	61687	1:1	84612	86.7	56218	93518	133.6	1.097	0.905	0.649
33	67770	1.05:1	93431	88.3	61928	102411	137.5	1.094	0.912	0.642
34	74926	1.05:1	103570	91.1	69044	113604	141.8	1.085	0.912	0.642
35	83558	1.05:1	115685	94.1	77564	126789	146.1	1.077	0.912	0.644
36	94100	1.05:1	130211	97.4	88052	142399	150.7	1.069	0.914	0.646
37	106949	1.05:1	147873	101.1	*100300*	*160943*	*155.6*	*1.066*	*0.919*	*0.649*
38	122400	1.05:1	169325	105.0	*114326*	*182105*	*160.7*	*1.071*	*0.930*	*0.653*
39	140564	1.025:1	195123	110.0	*130256*	*205829*	*166.0*	*1.079*	*0.948*	*0.663*
**Twin Screw Data (Italix) above 36 knots exceeds the cavitation limit*								1.100	0.896	0.648

APPENDIX B

Pod Bearing Forces

FIGURES OF APPENDIX B

TABLES OF APPENDIX B

Loads experienced by pods have been a significant concern in Naval adoption of podded propulsion, both transient shock loadings from underwater explosions and large quasi-static loadings due to the failure and uncontrolled azimuthing of a pod at speed. In order to examine bearing forces in cases representing malfunction angles, the pods were tested with extreme splay angles of 30, 60, and 90 degrees outboard. Propellers were operating at the self propulsion rpm as determined in the powering tests with the pods in the zero angle position.

Forces on the pod were measured by an x-y force gauge as shown in main body Figure 3. This gauge collar was mounted inside the hull immediately above the pod bearing tubes. Each gauge was mounted such that a thrust force generated by the pod was positive in the x direction, with the y direction following in a conventional right-handed coordinate system. This gauge rotates with the pod, so that bearing forces are recorded in a pod- rather than ship-fixed coordinate system. (Figure B-1) The gauge on the starboard pod was damaged during testing, so all results are derived from measurements taken on the port pod.

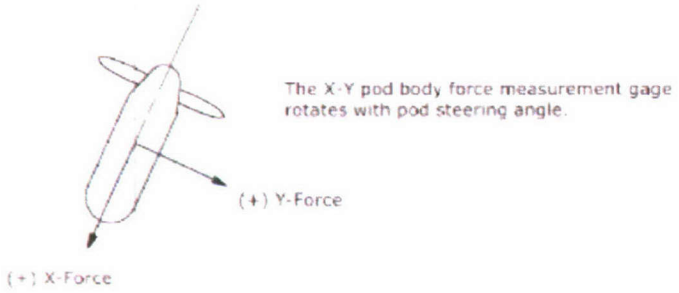

Fig. B-1. Pod force gauge sign convention and coordinate system

The flow about a rotated pod tended to produce a broad low-amplitude wave crest approximately one half station ahead of the pods' longitudinal center of rotation. At angles of 60 and 90 degrees, large ventilated cavities were observed to form behind the pods. High speed conditions had to be omitted as forces approached the limits of the measurement system, but a general trend of increasing bearing force with pod angle is obvious over the 1-60 degree range. The forces at the 90 degree splay angle are somewhat lower than those at 60 degrees, possibly as a result of lifting effects over the pod body at the 30- and 60 degree conditions.

Pod force data is presented in Table B-1 and Figures B-2-3 as model scale measurements. Because very few data points were taken, no fairing beyond speed averaging and the removal of obvious outliers has been applied to these values.

Table B-1 Pod Bearing Force Data

Model Speed	Port Drag Force	Port Side Force	Total Force Maginitude	Direction Clockwise from dead aft
(kts)	(LBF)	(LBF)	(LBF)	(DEG)
1 Degree Inboard				
2.582	-0.548	-0.027	0.549	182.815
3.433	-0.864	0.161	0.879	169.434
4.294	-1.289	-0.092	1.292	184.095
5.159	-1.932	0.409	1.975	168.053
6.181	-3.116	-0.027	3.116	180.501
6.703	-4.509	-0.420	4.529	185.323
7.218	-6.254	-0.866	6.314	187.883
30 Degrees Outboard				
2.579	3.862	-10.710	11.386	-70.170
3.427	6.121	-16.485	17.585	-69.628
4.293	8.380	-23.484	24.934	-70.361
5.157	11.159	-32.140	34.022	-70.853
6.181	14.581	-41.702	44.178	-70.728
60 Degrees Outboard				
2.579	12.251	-11.099	16.531	-42.174
3.430	19.841	-17.130	26.212	-40.806
4.292	26.836	-22.818	35.226	-40.374
5.157	31.193	-21.618	37.952	-34.724
90 Degrees Outboard				
2.583	14.112	-4.354	14.769	-17.146
3.429	22.244	-4.464	22.688	-11.347
4.294	31.059	-5.650	31.568	-10.310

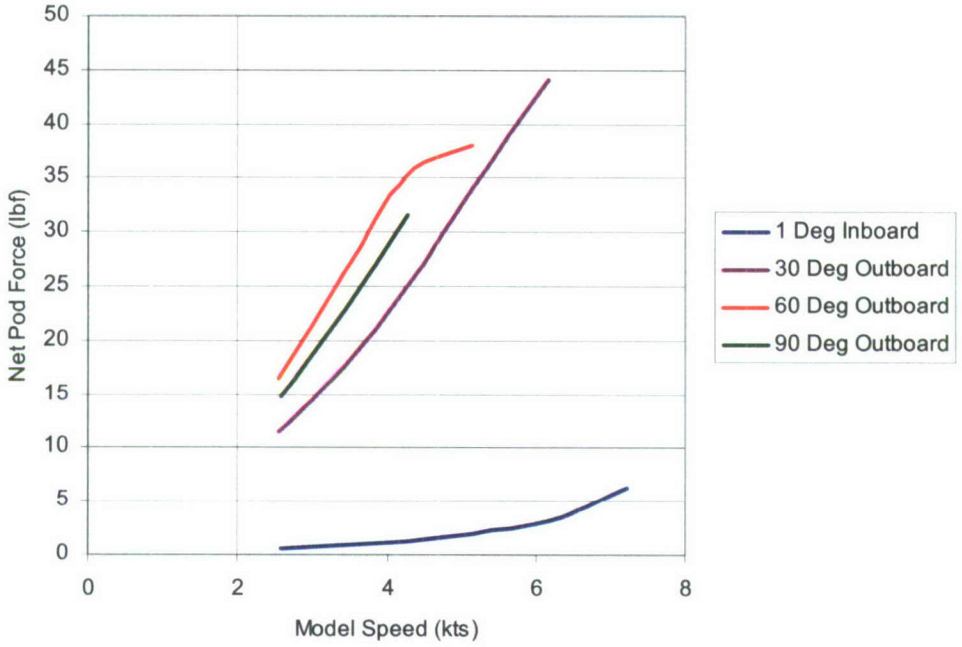

Fig. B-2. Pod bearing force magnitude as a function of speed. Note that the 1 Deg Inboard force operates primarily in the thrust direction, while the others are primarily drag forces.

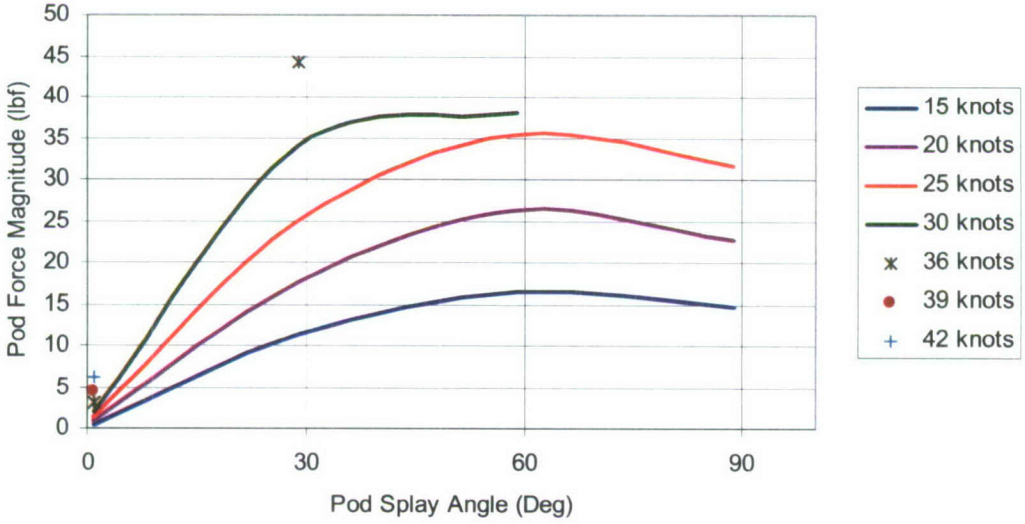

Fig. B-3. Pod bearing force as a function pod splay angle

The steering angle tests (see main body of report) indicate that even small increases in pod angle lead to a loss of powering efficiency. This is borne out at large angles as well. The pods produce a net propulsive thrust only in the baseline position. Even at 30 degrees outboard, with the propellers still aligned in a more or less useful direction, the net force on the pods is in the drag direction. This is probably due to a combination of extremely poor inflow to the propeller and lifting forces on the pod body and ventilation at higher splay angles.

These complex effects are unlikely to scale rigorously by traditional rules, but using treating the net pod drag as a component of residuary resistance and scaling by the conventional $\frac{1}{2} \cdot \rho \cdot S \cdot V^2$ yields extremely large predictions for ship scale pod forces. (Table B-2)

Table B-2 Predicted ship scale pod bearing forces

Model Speed (kts)	Pod Force Coefficient	Ship Speed (kts)	Ship Scale Force (lbf)
Pods 1 Deg Inboard			
2.582	3.11E-04	15.1	2.24E+04
3.433	2.82E-04	20.1	3.58E+04
4.294	2.65E-04	25.1	5.27E+04
5.159	2.80E-04	30.1	8.05E+04
6.181	3.08E-04	36.1	1.27E+05
6.703	3.81E-04	39.2	1.85E+05
7.218	4.58E-04	42.2	2.57E+05
Pods 30 Deg Outboard			
2.579	6.46E-03	15.1	4.64E+05
3.427	5.65E-03	20.0	7.17E+05
4.293	5.11E-03	25.1	1.02E+06
5.157	4.83E-03	30.1	1.39E+06
6.181	4.37E-03	36.1	1.80E+06
Pods 60 Deg Outboard			
2.579	9.39E-03	15.1	6.74E+05
3.430	8.41E-03	20.0	1.07E+06
4.292	7.22E-03	25.1	1.44E+06
5.157	5.39E-03	30.1	1.55E+06
Pods 90 Deg Outboard			
2.583	8.36E-03	15.1	6.02E+05
3.429	7.29E-03	20.0	9.25E+05
4.294	6.47E-03	25.1	1.29E+06

Pod forces predicted in the manner are several times greater than the fully appended bare hull resistance of the ship with the pods at their zero angle. (Figure B-4) This magnitude seems excessive, and may be due to the simple scaling methodology employed.

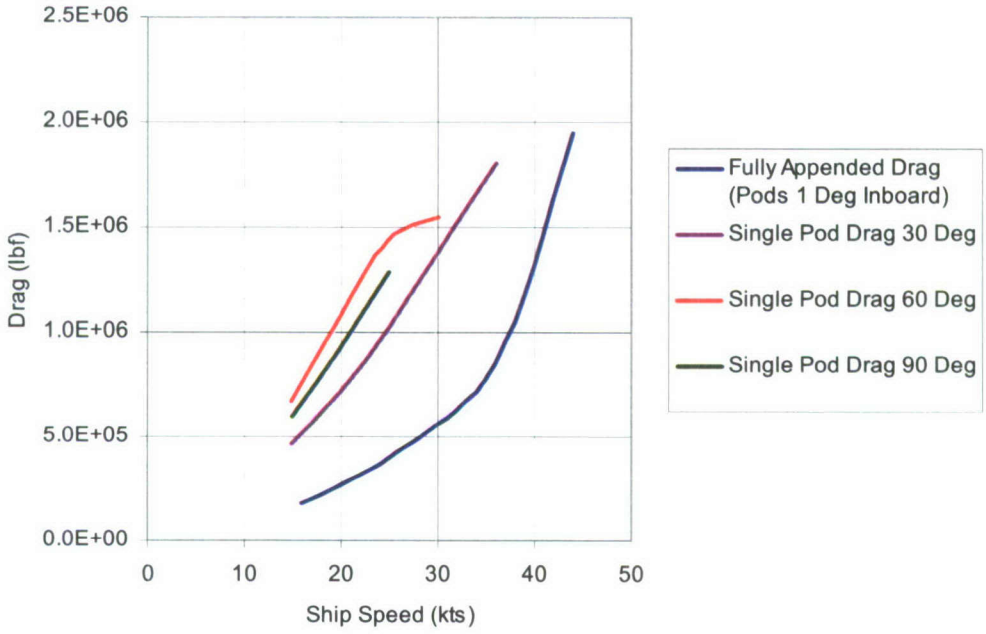

Fig. B-4. Pod bearing forces scaled as residuary resistance component compared to ship drag.

Further investigation is necessary in order to state full scale quantitative results with confidence, but it obvious that pods operating broadside to the flow will present massive drag and experience very large hydrodynamic forces.

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